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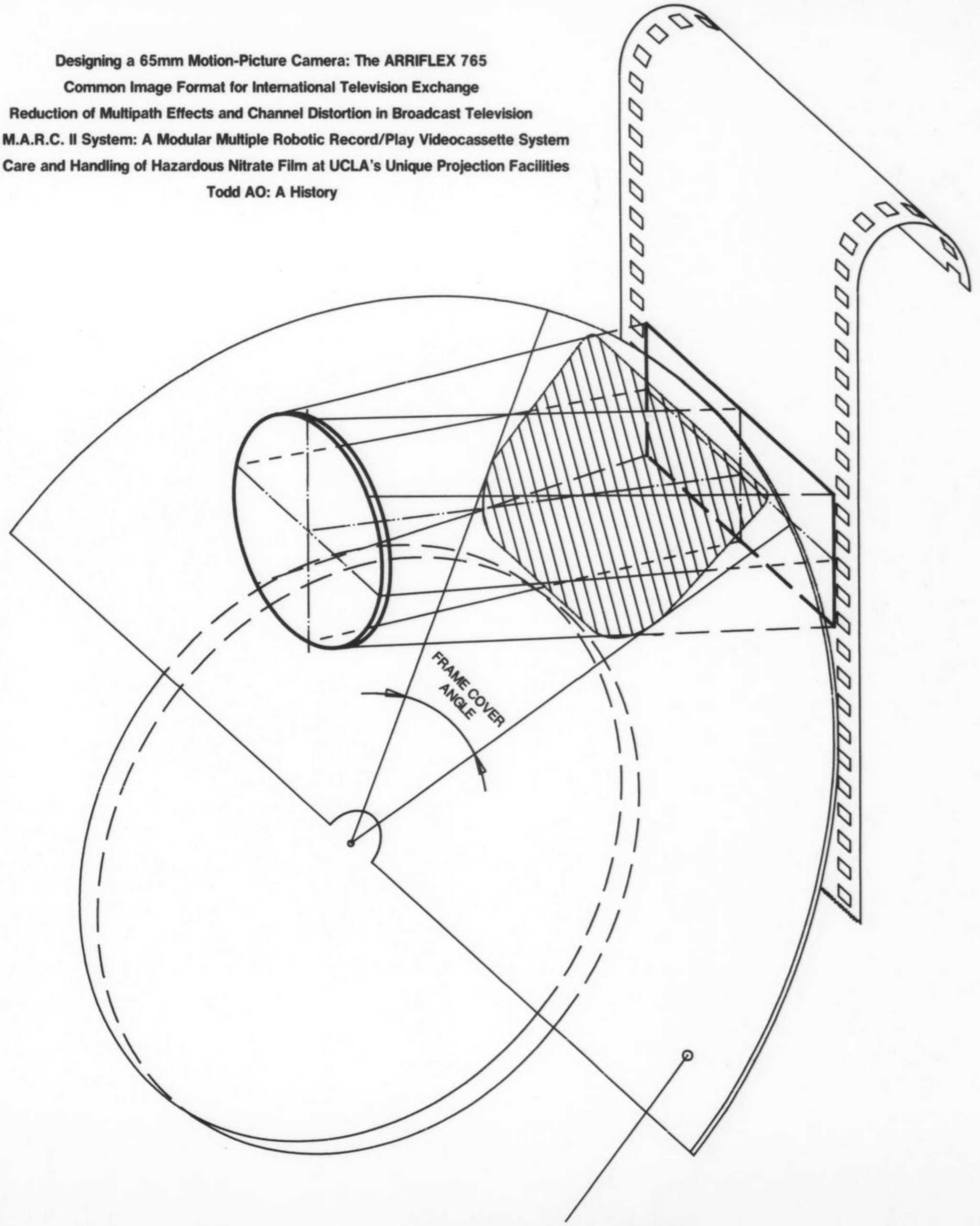

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Calendar

June

HDTV '90, Fourth International Colloquium on Advanced Television Systems, Ottawa Congress Center, Ottawa, Canada. Info: Secretariat HDTV '90, c/o Conference Coll Inc., 1138 Sherman Dr., Ottawa, Ont. K2C 2M4, Canada. *June 25–29, 1990.*

July

Sound & Vision '90, Fourth Conference and Exhibition of the SMPTE's Australian Section, RAS Showground, Sydney, Australia. Info: Sara Godfree, Exhibition Manager, World Trade Promotions, 144 Riley St., East Sydney, NSW 2010, Australia. *July 3–6, 1990.*

Video Expo Chicago, Expo Center, Chicago, Ill. Info: Ellen Greenfield, Knowledge Industry Publications, 701 Westchester Ave., White Plains, NY 10604. *July 23–27, 1990.*

ITEC'90, ITE Annual Convention, Chuo University, Tokyo, Japan. Info: Institute of Television Engineers of Japan, Room 209, Kikai-Shinko-Kaikan, 3-5-8, Shiba, Minato-ku, Tokyo 105, Japan. *July 25–27, 1990.*

August

Video Expo '90, Third International Fair of Video and Television Equipment, Convention Center of Anhembi, São Paulo, Brazil. Info: Certame International Exhibitions System, Inc., 60 E. 42nd St., Suite 4511, New York, NY 10165. *August 19–22, 1990.*

6th Annual Rocky Mountain Film & Video Expo, John Q. Hammons Trade Center, Denver, Colo. Info: Jessica Lucerne, Rocky Mountain Film & Video Expo, P.O. Box 10545, Denver, CO 80210. *August 28–29, 1990.*

8th Seoul International Broadcast, Telecommunications, Audiovisual, and Motion Picture Equipment Exhibition, Korea Exhibition Center, Seoul, Korea. Info: Secretariat of SIBTA, K.P.O. Box 1808, Seoul, Korea. *August 31– September 2, 1990.*

September

Video Expo New York, Jacob K. Javits Convention Center, New York City. Info: Ellen Greenfield, Knowledge Industry Publications, 701 Westchester Ave., White Plains, NY 10604. *September 10–14, 1990.*

IBC 90, Metropole Conference and Exhibition Center, Brighton, England. Info: IBC Secretariat, Institution of Electrical Engineers, Savoy Place, London WC2R OBL, England. *September 21–25, 1990.*

89th Audio Engineering Society Convention, Los Angeles Convention Center, Los Angeles, Calif. Info: Ron Streicher, AES Convention Chairman, 545 Cloverleaf Way, Monrovia, CA 91016. *September 21–25, 1990.*

October

Society of Broadcast Engineers, 5th Annual Convention, Cervantes Convention Center, St. Louis, Mo. Info: Eddie Barker, Exhibits Manager, 2515 McKinney Ave., Suite 1285, Lock Box 12, Dallas, TX 75201. *October 4–7, 1990.*

132nd SMPTE Technical Conference and Equipment Exhibit, Jacob K. Javits Convention Center, New York City. Info: SMPTE, 595 W. Hartsdale Ave., White Plains, NY 10607. *October 13–17, 1990.*

5th International Broadcasting and Telecommunications Show, South Pavilion of the Milan Fair at Lacchiarella. Info: Segreteria Generale, IBTS, Via Domenichino 11, 20149 Milan, Italy. *October 18–22, 1990.*

February 1991

25th Annual SMPTE Television Conference, Westin Detroit Hotel, Detroit, Mich. Info: SMPTE, 595 W. Hartsdale Ave., White Plains, NY 10607. *February 1–2, 1991.*

4th International Workshop on HDTV and Beyond, Turin, Italy. Info: Hiroshi Yasuda, NTT Human Interface Laboratories, 1-2356 Take Yokosukasi, 283-03 Japan. *February 27–March 1, 1991.*

June 1991

17th International Television Symposium and Technical Exhibition, Montreux, Switzerland. Info: International Television Symposium and Technical Exhibition, P.O. Box 97, Rue du Theatre 5, CH-1820 Montreux, Switzerland. *June 13–18, 1991.*

4th International Conference on Television Measurements, Montreux, Switzerland. Info: Louise Bousefield, Institution of Electrical Engineers, Savoy Place, London WC2R OBL, England. *June 20–22, 1991.*

SMPTE Conferences

132nd Technical Conference and Equipment Exhibit, Jacob K. Javits Convention Center, New York City. *October 13–17, 1990.*

25th Annual Television Conference, Westin Detroit Hotel, Detroit, Mich. *February 1–2, 1991.*

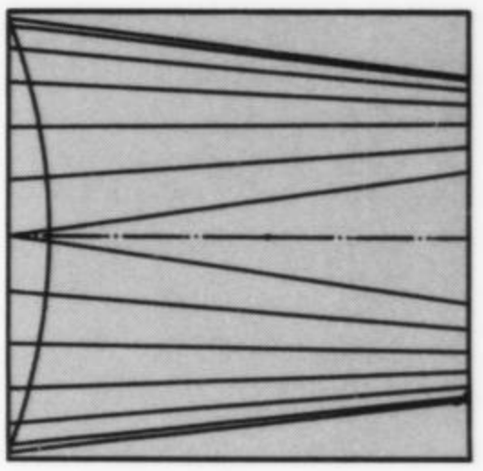
133rd Technical Conference and Equipment Exhibit, Los Angeles Convention Center, Los Angeles, Calif. *October 26–30, 1991.*

26th Annual Television Conference, St. Francis Hotel, San Francisco, Calif. *February 7–8, 1992.*

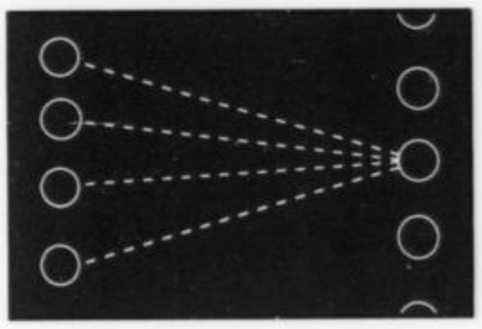
134th Technical Conference and Equipment Exhibit, Metro Toronto Convention Centre, Toronto, Ont., Canada. *November 10–14, 1992.*

Highlights

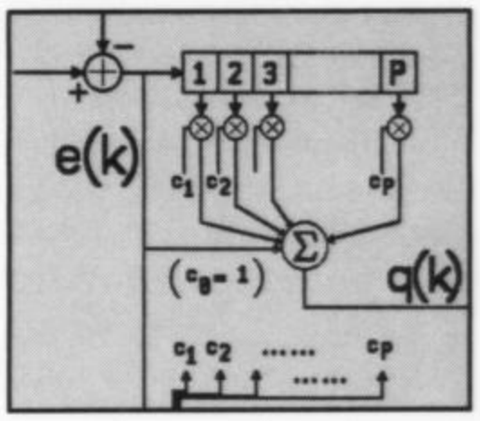
428 **Designing a 65mm Motion-Picture Camera: The ARRIFLEX 765** • *K. H. Ropin* • Design of the ARRIFLEX 765 65mm camera was a challenging engineering task. This article outlines how a single pulldown claw can accommodate rates of 2 to 100 frames/sec at standard loop adjustment. Development of this pulldown claw involved determining the force rate required and designing a film-transport system having a double-sided, one-toothed registration pin and a double-sided, three-toothed pulldown claw. Picture steadiness of <0.1% of frame height and noise level <25 dBA at 24/25 frames/sec were achieved. Use of ball bearings rather than slide bearings makes the camera maintenance-free for an extended period.



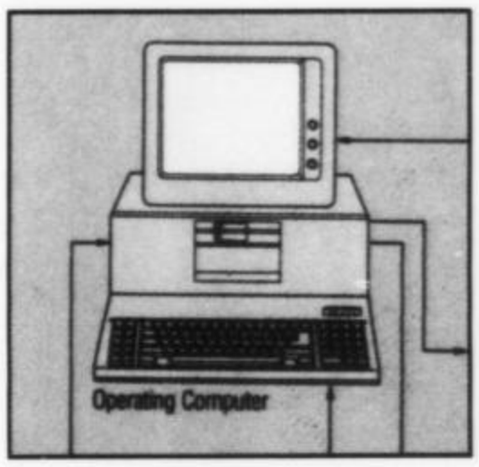
438 **Common Image Format for International Television Program Exchange** • *S. N. Baron and K. H. Powers* • A proposal is made for a set of high-definition production and international television program exchange standards that incorporate the concept of common image format (CIF), but also employ a common data rate (CDR) for recording and distribution. The issues of processing headroom, blanking transitions, and line-rate conversion to other formats and standards are examined.



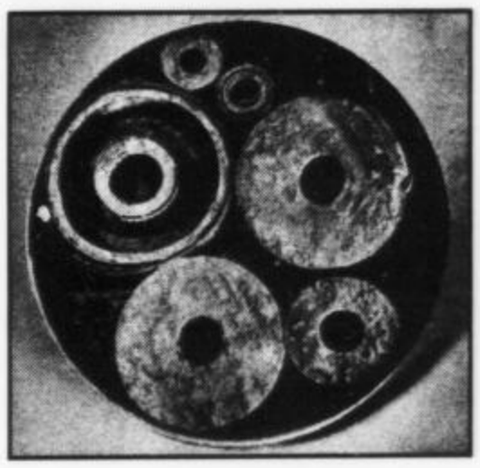
442 **Reduction of Multipath Effects and Channel Distortion in Broadcast Television** • *M. Pazarci* • A new technique for the adaptive recursive removal of ghosts, using look-up and decision-based adaptive assignment of the parameters of the recursive algorithm, is described. A coarse channel estimation is used to select the initial parameter set. The algorithm requires a training signal in the vertical blanking interval. A master control algorithm keeps track of the echo-channel and system parameters and makes the necessary control decisions and echo assignments. Two-axis synchronous detection is used, and the echo-reduction operation is performed in the baseband.



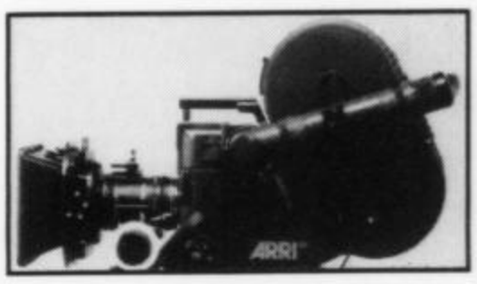
448 **The M.A.R.C. II System: A Modular Multiple Robotic Record/Play Videocassette System** • *P. Livingston, M. Notani, M. Min, and M. Mifflin* • Given that broadcast television operations are looking increasingly toward automation as an alternative mandated by economics, the previous generation of automatic cartridge or cassette playback systems have become outdated. By building on existing robotic technology, a reliable, deliverable system has been brought to fruition. By utilizing a modular library, the system can be configured to meet individual requirements, and combining off-the-shelf operating system software with a readily available desktop computer has contributed to the rapid development and reliability of the overall system.



453 **The Care and Handling of Hazardous Nitrate Film at UCLA's Unique Projection Facilities** • *J. Daily* • The UCLA Film Archive houses many nitrate films that are screened regularly in the university's Melnitz Theater. Since nitrate prints are extremely flammable, precautions must be taken each time they are projected. When nitrate burns, it produces its own oxygen and therefore cannot be extinguished. The Melnitz projection booth required extensive modifications in order to meet safety codes required for screening nitrate films. The modifications included the installation of a steel firedoor with ports, which is lowered into position when nitrate film is present in the booth. A special interlock system was designed to prevent projection of nitrate if the fire door is not in position.



457 **Todd-AO: A History** • *J. Belton* • Using 65mm camera film, specially designed wide-angle lenses, and six-track stereo magnetic sound, the Todd-AO system was first used to film *Oklahoma*, which was released in 1955. The success of this and a handful of subsequent Todd-AO films led to the introduction and establishment of a new wide-film standard of 70mm, which survives today as a major format for motion-picture presentation in the theater.



Designing a 65mm Motion-Picture Camera: The ARRIFLEX 765

By Kurt H. Ropin

Design of the ARRIFLEX 765 65mm camera was a challenging engineering task. This article outlines how a single pulldown claw can accommodate rates of 2 to 100 frames/sec at standard loop adjustment. Development of this pulldown claw involved determining the force rate required and designing a film-transport system having a double-sided, one-toothed registration pin and a double-sided, three-toothed pulldown claw. Picture steadiness of <0.1% of frame height and noise level <25 dBA at 24/25 frames/sec were achieved. Use of ball bearings rather than slide bearings makes the camera maintenance-free for an extended period.

In designing the ARRIFLEX 765 65mm motion-picture camera, a major goal was to develop a movement (five-perforation pulldown) using a single claw for rates of 2 to 100 frames/sec at a standard loop adjustment. Other objectives were picture steadiness of ≤0.1% of frame height, optimum definition, a noise level of ≤25 dBA at 24/25 frames/sec, and a movement that is maintenance-free for the time required to make a motion picture. This article describes how this was accomplished.

Frame Rate

To achieve rates of 2 to 100 frames/sec, the design had to combine the movements of two types of cameras — a standard camera providing up to 50 frames/sec and a high-speed camera for up to 100 frames/sec — in a single system.

Determining the Force Required

A key factor in the design was the force required in terms of frame rate. It would have been pointless simply to double the force required for the standard 35mm format, so the actual force required for the 65mm format had to be determined.

Any comparison of the forces required for the 35 and 65mm formats must be based on the laws of physics: force required increases by speed squared (frame rate). The force increases proportionately to the longer pulldown and the bigger path mass of the film. Table 1 compares the operands for the two formats.

The following calculations are based on a factor of 2 for the 65mm format film mass (width factor=1.85), since the longer pulldown and the resulting longer loop double the film mass to be moved per step as compared to the 35mm format. Table 2 compares the forces required for the two formats at rates between 25 and a maximum of 100 frames/sec. The standard rate of 25 frames/sec for the 35mm format is given the force factor 1 for use as a starting point for comparisons.

Doubling the rate to 50 frames/sec requires quadrupling the force:

25:50 fps = 1:2
$2^2 = 4$

Comparing the 35 and 65mm formats at 25 frames/sec *directly* gives:

35mm force factor = 1.0 (Table 2)
65mm force factor = (fps factor) × (film mass × 2) × (5/4 longer pulldown)
$X = 1 \times 2 \times 5/4$
$X = 2.5$

At 25 frames/sec, the pulldown claw thus requires 2.5 times the force for the 65mm format as compared to the 35mm format.

Comparing the 35 and 65mm formats *directly* for maximum rates of 50 frames/sec (for a traditional 35mm camera) and 100 frames/sec (desired maximum of the ARRIFLEX 765) gives:

35mm, 50 fps: force factor = 4 (Table 2)
65mm, 100 fps: force factor = (fps factor) × (film mass × 2) × (5/4 longer pulldown)
fps factor = $2^2 = 4$
$X = 4 \times 2 \times 5/4$
$X = 10$

This comparison of maximum frame rates shows that the force required for 100 frames/sec in the 65mm format is significantly (ten times) higher than for 50 frames/sec in the 35mm format. This conclusion confirms that the force factor for the

Table 1 — Operands for Formats

	35mm	65mm
Perforations	4	5
Width factor	1 (base)	1.85 (65/35)

Table 2 — Forces Required for the 35 and 65mm Formats

Format (mm)	Frame Rate (fps)	Force Factor
35	25	1.0
35	50	4.0
65	25	2.5
65	50	10.0
65	100	40.0

Presented at the 131st SMPTE Technical Conference in Los Angeles (paper no. 131-30) on October 21, 1989. Kurt H. Ropin is with ARRI-Austria, Vienna, Austria. Copyright © 1990 by the Society of Motion Picture and Television Engineers, Inc.

35mm format is 4, while for the 65mm format it is 40. In short, the 65mm format requires 2.5 to 10 times the force of a traditional 35mm format, which makes claw design a technically demanding problem.

Another problem was providing optimum transfer of force to the film. To achieve a rate of 100 frames/sec, the supporting surfaces of the claw points had to be optimized.

Developing an Ideal Pulldown Claw

To design a pulldown claw, it was necessary to determine the transport angle, calculate and define the optimum pulldown-claw path, and optimize the claw arm.

Determining the Transport Angle

The transport angle is the range covered by the spindle of the movement from insertion to release of the pulldown claws. It depends mainly on frame size, although the diameter and tilt of the reflex mirror shutter (RMS) are other major parameters to be taken into consideration.

In calculating the frame-covering angle, the tilt of the RMS was first defined. At 45°, the incoming light would be reflected vertically upward. This is impossible, however, due to the size of the groundglass and the design of the viewfinder. To find the optimum position for the viewfinder and groundglass, the upward reflection had to be slanted forward by 5°. Consequently, the RMS is tilted by 42.5°.

In dimensioning the RMS (Fig. 1), the mirror must cover the upper and lower edges of the film frame completely. The lower edge of the frame also serves as the boundary for the RMS hub. The hub diameter should be sized so as to minimize any deformation of the mirror due to centrifugal forces and its one-sided connection to the hub.

Deformations caused by the Coriolis force during fast panning at high frame rates also had to be kept to a minimum. If such deformations exceed a certain limit, the viewfinder picture may be distorted and the RMS may graze the flag to the inner camera. Accordingly, the optimum proportion between the hub diameter and the mirror diameter is approximately 1:2.

The frame-cover angle (Fig. 2) was then calculated by means of a chart. The rotating circular RMS, due to its tilt, projects an elliptical plane, accepting or restricting the incoming light as a slant, so that the frame-

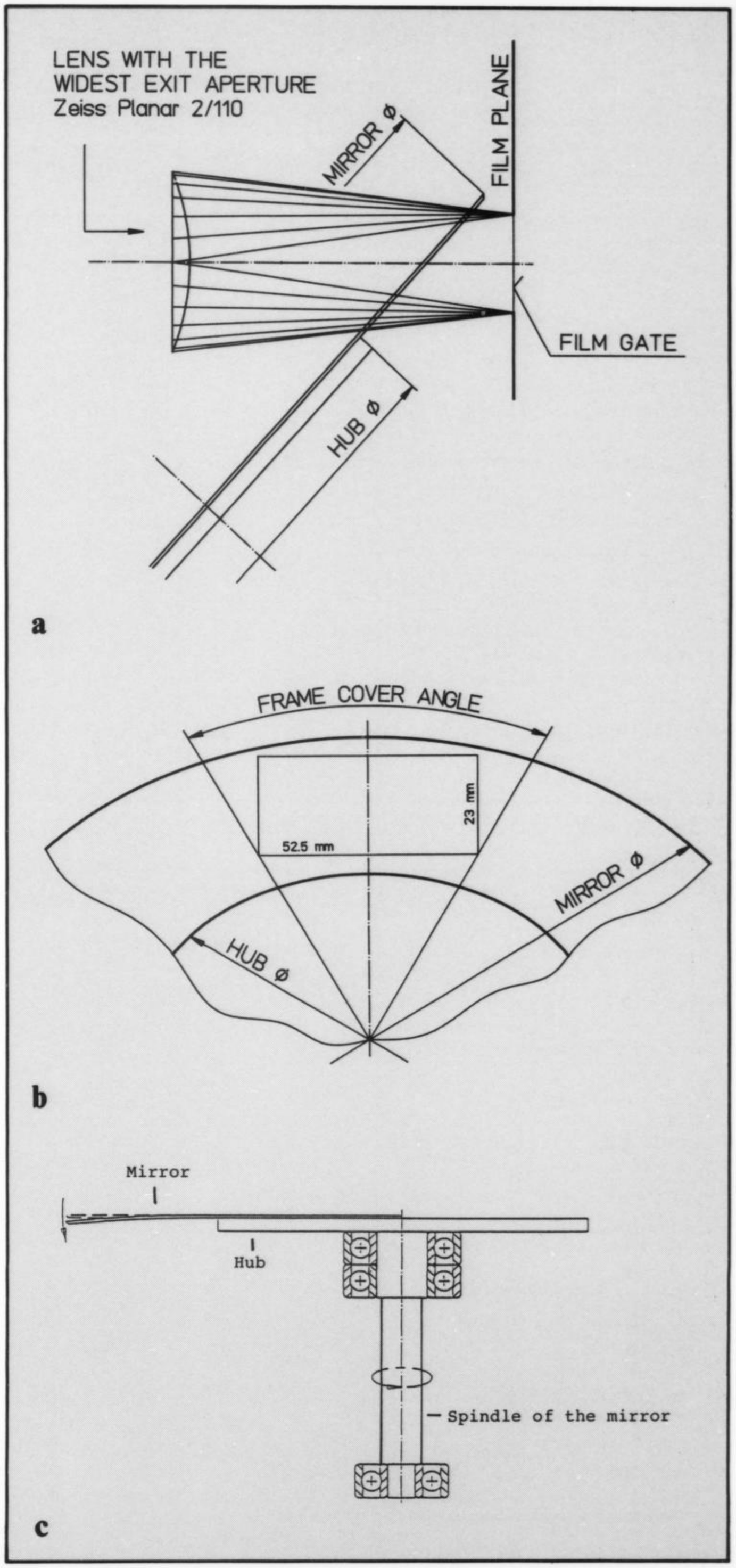


Figure 1. Reflex mirror shutter: (a) side view, film gate; (b) front view, frame-cover angle; (c) side view of deformation of the mirror (exaggerated).

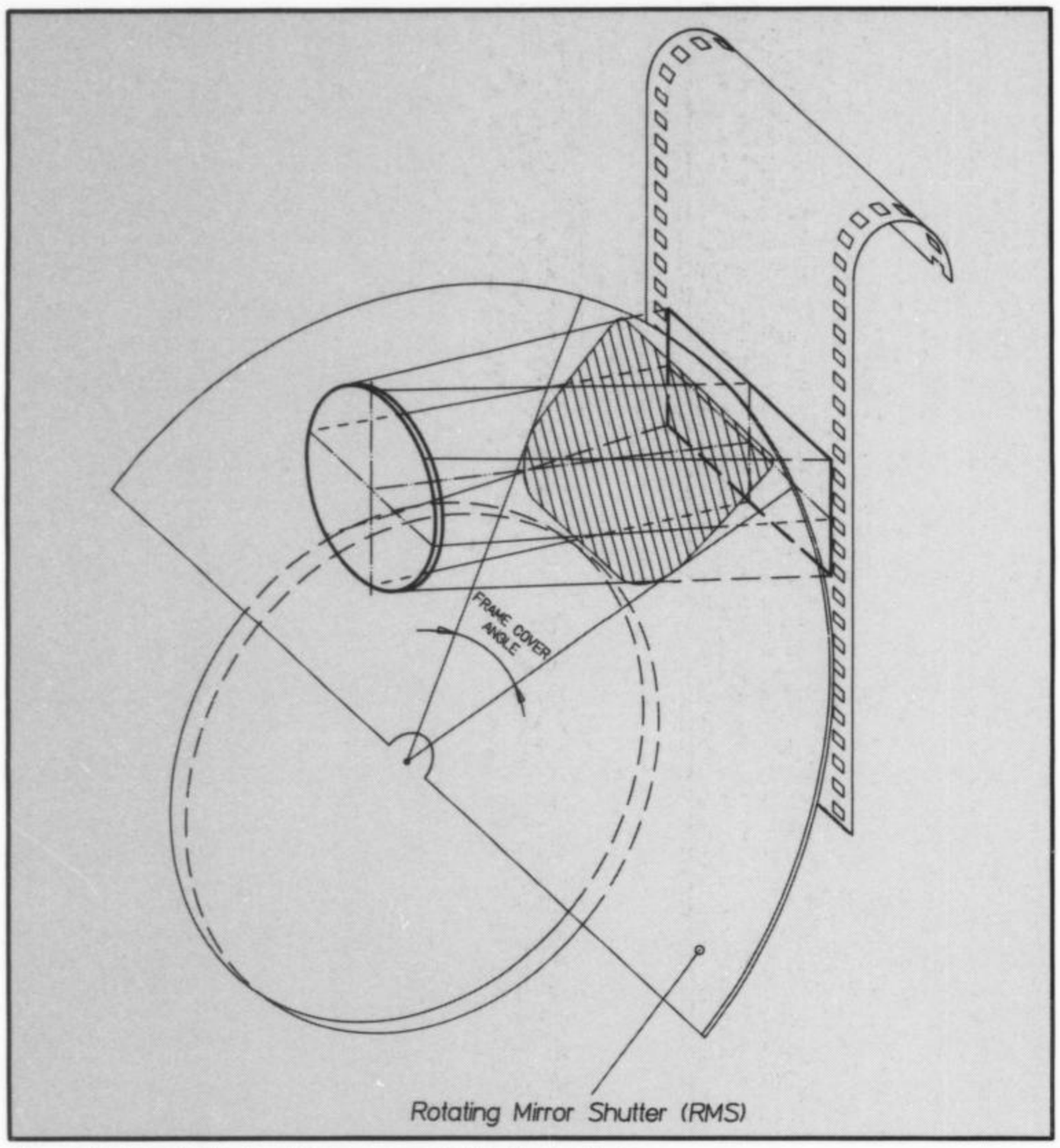


Figure 2. Calculating the frame cover angle, diagonal view.

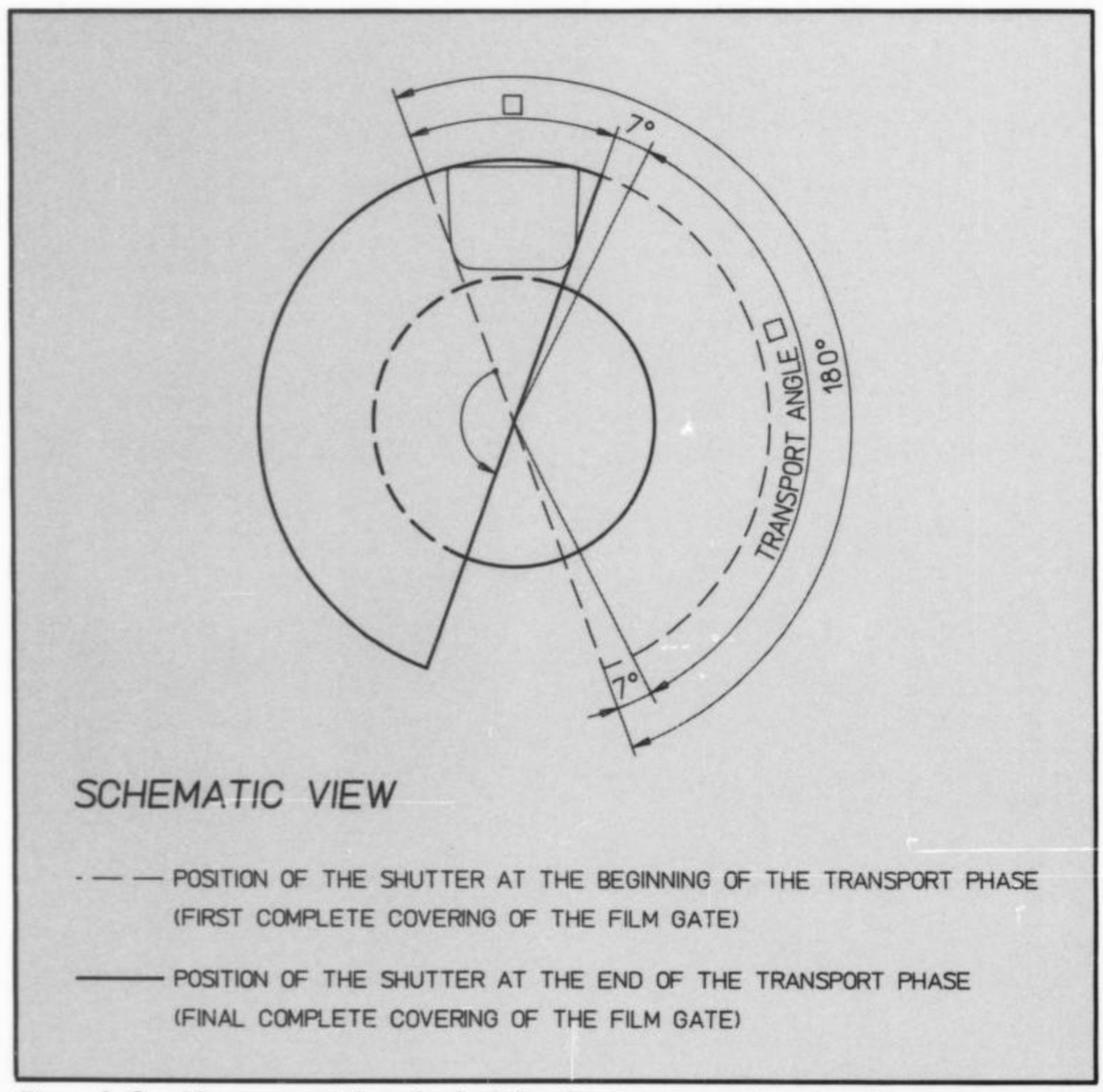

7°
TRANSPORT ANGLE
180°
7°
SCHEMATIC VIEW
- — — POSITION OF THE SHUTTER AT THE BEGINNING OF THE TRANSPORT PHASE
(FIRST COMPLETE COVERING OF THE FILM GATE)
——— POSITION OF THE SHUTTER AT THE END OF THE TRANSPORT PHASE
(FINAL COMPLETE COVERING OF THE FILM GATE)

Figure 3. Graphic representation of calculating the transport angle, schematic view.

cover angle, calculated theoretically according to Fig. 1b, may be reduced, in practice, by 4°. Starting from the frame-cover angle α, already defined, the maximum aperture angle (180°), and the tilt of the RMS, the pulldown-claw transport angle β (Fig. 3) was calculated. Table 3 shows an example of this calculation.

The registration-pin adjustment phase was a key factor in determining the transport angle as it affects picture steadiness. If the 9° angle had not been taken into account, the result might have been inaccurate exposures as the film would still be in the process of adjustment at the beginning of exposure.

Calculating and Defining the Optimum Pulldown-Claw Path

Based on experience acquired during years of designing and building 35mm cameras, development of an efficient movement system for the 65mm camera began. To illustrate the complicated geometric principle operating on the pulldown claw, the claw is represented as a five-link chain with two claw points (Fig. 4). Using the five-chain link, a computer program was developed to calculate a schematic claw path. Key parameters such as transport angle and transmission angle were recorded exactly for one rotation of the claw.

As the objective was use of a single claw for rates between 2 and 100 frames/sec, the ARRIFLEX 765 actually is a combination of two cameras. Finding an optimum design for the claw path was of decisive importance, considering the wide span of frame rates to be accommodated. It was essential to find the optimum claw path that would satisfy the high requirements of frame rates and picture steadiness and ensure precise, low-noise insertion, release, and movement of the film stock at all times.

Figure 5 illustrates the interplay between the geometric design of the claw and the claw path. As the claw path is judged by its insertion and release positions, Figs. 6 and 7 show insertion and release separately to monitor their precise routes.

The computer program established that the transport angle, at 140°, was too large (the calculated optimum was 125.5°). The pulldown claw released the film while it was still being pulled down, so the radius of the film channel (R) had to be changed (Fig.

7). The illustrations (Figs. 6 and 7) of the schematic claw path clearly show where the path deviated from the optimum route.

For insertion and release of the first claw point (Fig. 6), the path curve peaked in front of the film channel, so that the registration pin had to correct the inaccuracy of the pulldown claw. This would have produced noise and might have affected film movement at high frame rates. For insertion of the second claw point (Fig. 7), the path again peaked in front of the film channel, and the film was released while still being pulled down.

Such inaccuracies made it necessary to alter the claw path. The horizontal cam was enlarged (by tenths of a millimeter), which reduced the transport angle, and the vertical cam was made smaller to keep pulldown at the same level.

Path Version 1. Figures 8 and 9 illustrate the effect of these alterations on the path curve. Insertion and release of the first claw point and insertion of the second point were now placed optimally. The transport angle was optimized as well. Still lacking, however, was the parallel movement of the claw path to the film channel. The second claw point was released while pulldown was still in progress.

Accordingly, the path was further refined as follows:

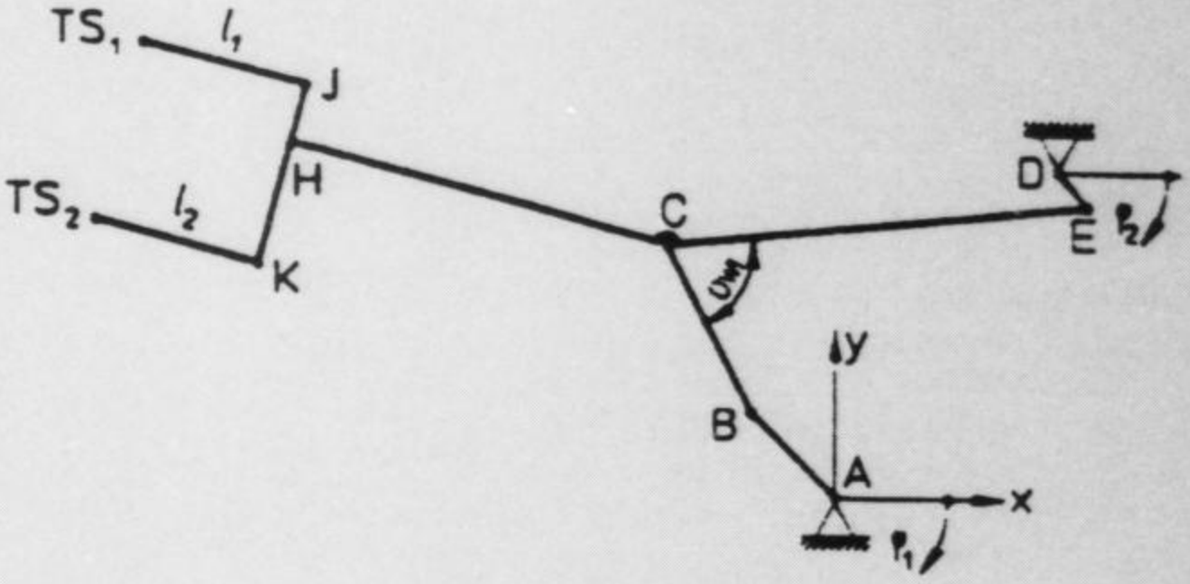
- The film channel radius (R) was cut from 50 to 43 mm to reestablish the parallel movement of the claw path vis-à-vis the film channel and to optimize the release of the second claw point.
- The claw was rotated to get an ideal path within the new film channel radius of 43 mm. The control points were also shifted.
- A third claw point was added (discussed below).

Path Version 2. Figure 10 shows the paths of the three claw points, which are all placed optimally toward the film channel. The first point is now inserted ideally, while the release is optimized by a slight correction of the top edge of the point. The path of the second point is ideal for both insertion and release. The third point is inserted a little later. This is not a problem, as two points are able to transmit the acceleration for the short period until the third point is inserted.

Any modification in the claw design had to take the transmission angle (see legend Fig. 4 — ÜWI — angle between connecting tool and trans-

Table 3 — Sample Calculation of the Transport Angle

Mirror angle (360°— aperture angle)	180.0°
Frame cover angle	−40.5°
Registration pin adjustment phase	−9.0°
Safety margin for deviations and manufacturing tolerances	−5.0°
Transport angle	125.5°



Ax/Ay = coordinates for the vertical movement cam
Dx/Dy = coordinates for the horizontal movement cam
AB = radius of vertical cam
BC = connecting rod of vertical cam
DE = radius of horizontal cam
CE = distance between bearings
CH = length of transport arm
HJ = position of first point
HK = position of second point
I_1 = length of first point
I_2 = length of second point
TS_1 = first pulldown claw point, TS_2 = second pulldown claw point
φ_1 = angle between horizontal level and vertical cam in insertion position
φ_2 = angle between horizontal level and horizontal cam in insertion position
$\hat{U}WI$ = transmission angle (angle between connecting rod and transport arm

Figure 4. Schematic diagram of the five-link chain.

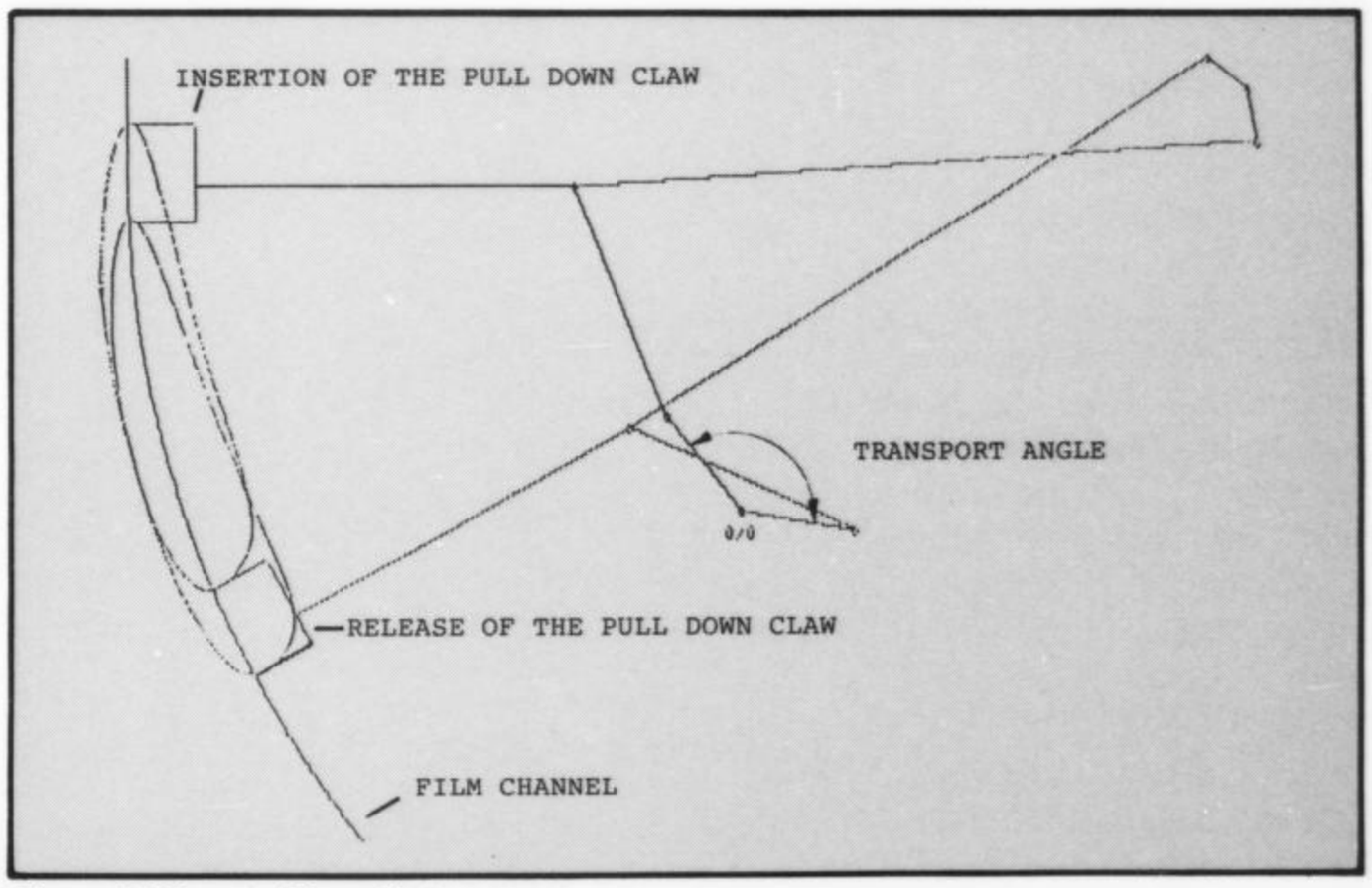


Figure 5. Claw positions, first concept.

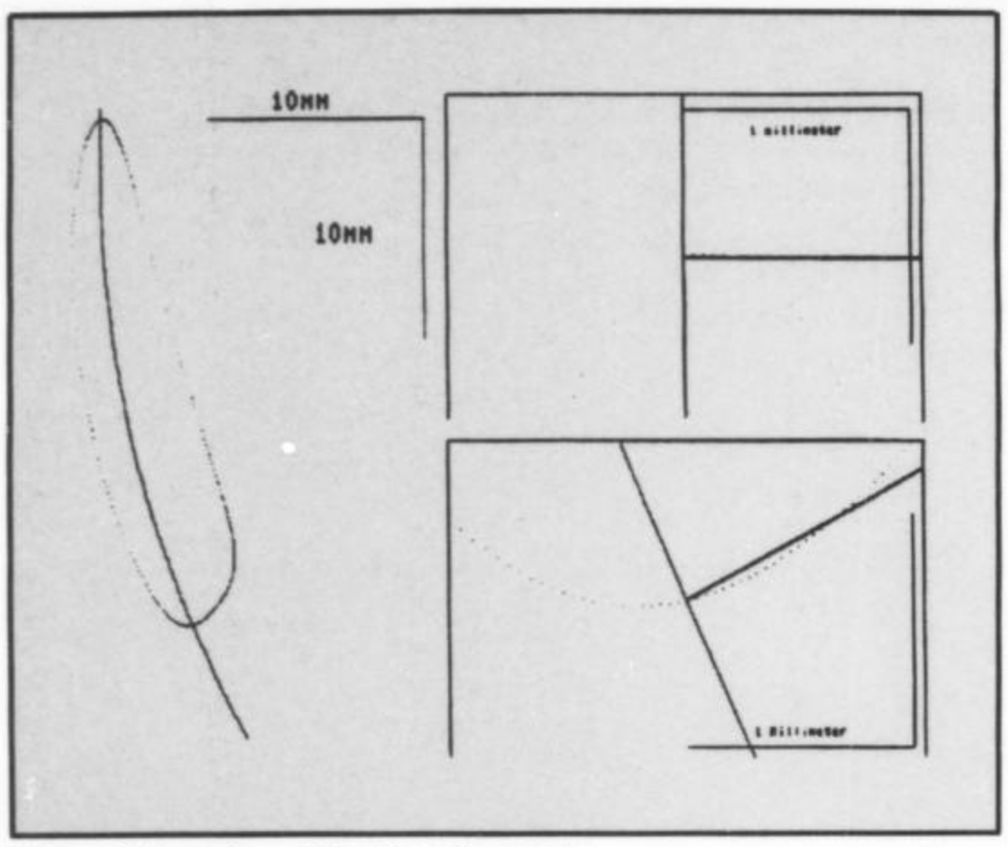


Figure 6. Insertion of the first claw point.

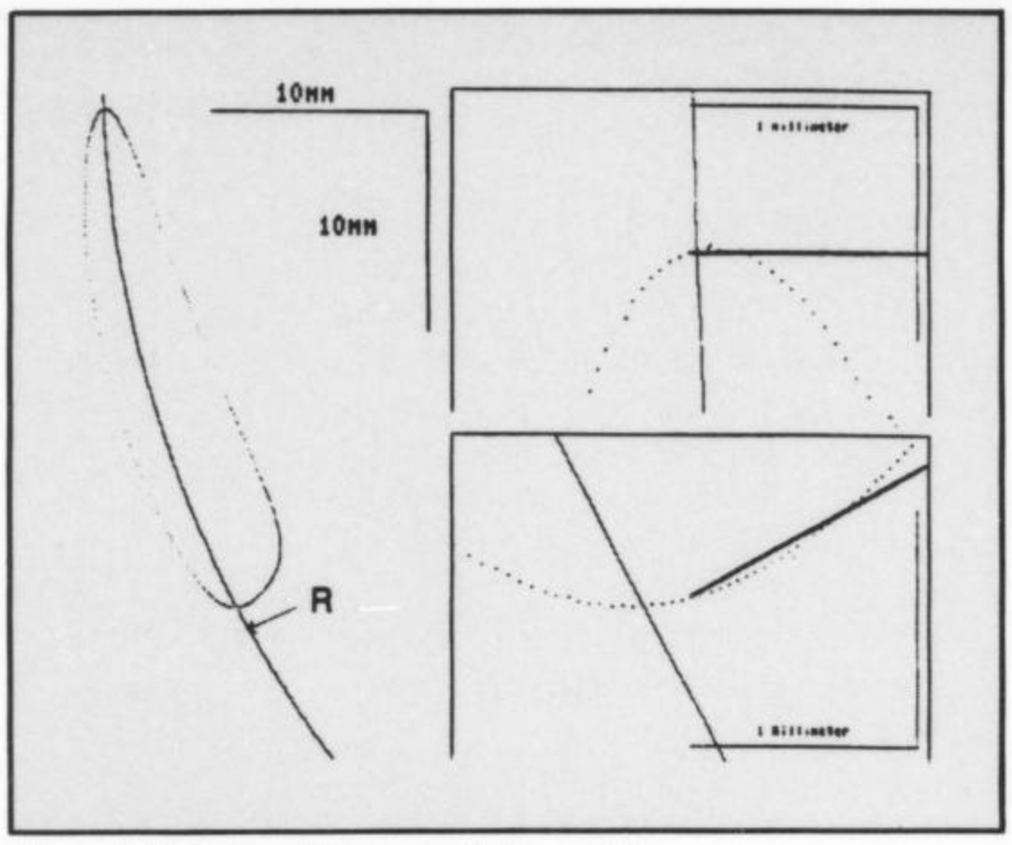


Figure 7. Release of the second claw point.

port arm) into account. To avoid claw instability, its minimum must never fall significantly below 30°. The claw must also be in an idle phase (neither accelerating nor decelerating) while the transmission angle is at its minimum: any forces applied during this position would have a high impact on the bearings and would thus increase wear and tear.

Optimizing the Pulldown-Claw Arm: Weight, Stability, and Deformation

The initial design (Fig. 11) of the claw arm was based on calculations of bearing and cam dimensions and the need for three claw points.

A rate of 100 frames/sec subjects the claw bearings to centrifugal forces as well as to forces generated by movement of the film stock. These forces break down as follows: 50% are centrifugal, caused by the movement of the claw arm, connecting rod, and ball bearings; and 50% are lateral, caused by the movement of the film stock (discussed below). Such forces posed a problem to the claw arm: continual operation would have broken it. Thus its design had to be improved.

In view of this distribution of forces generated during film movement, a 40% reduction in the weight of the pulldown-claw mechanism (claw arm, bearing, and connecting rod) allowed the forces acting on the claw bearings to be cut by 20%. Because of this reduction, the claw bearings could be designed in smaller dimensions to improve the weight, stability, and deformation characteristics of the claw arm (Fig. 12).

Weight was reduced by designing

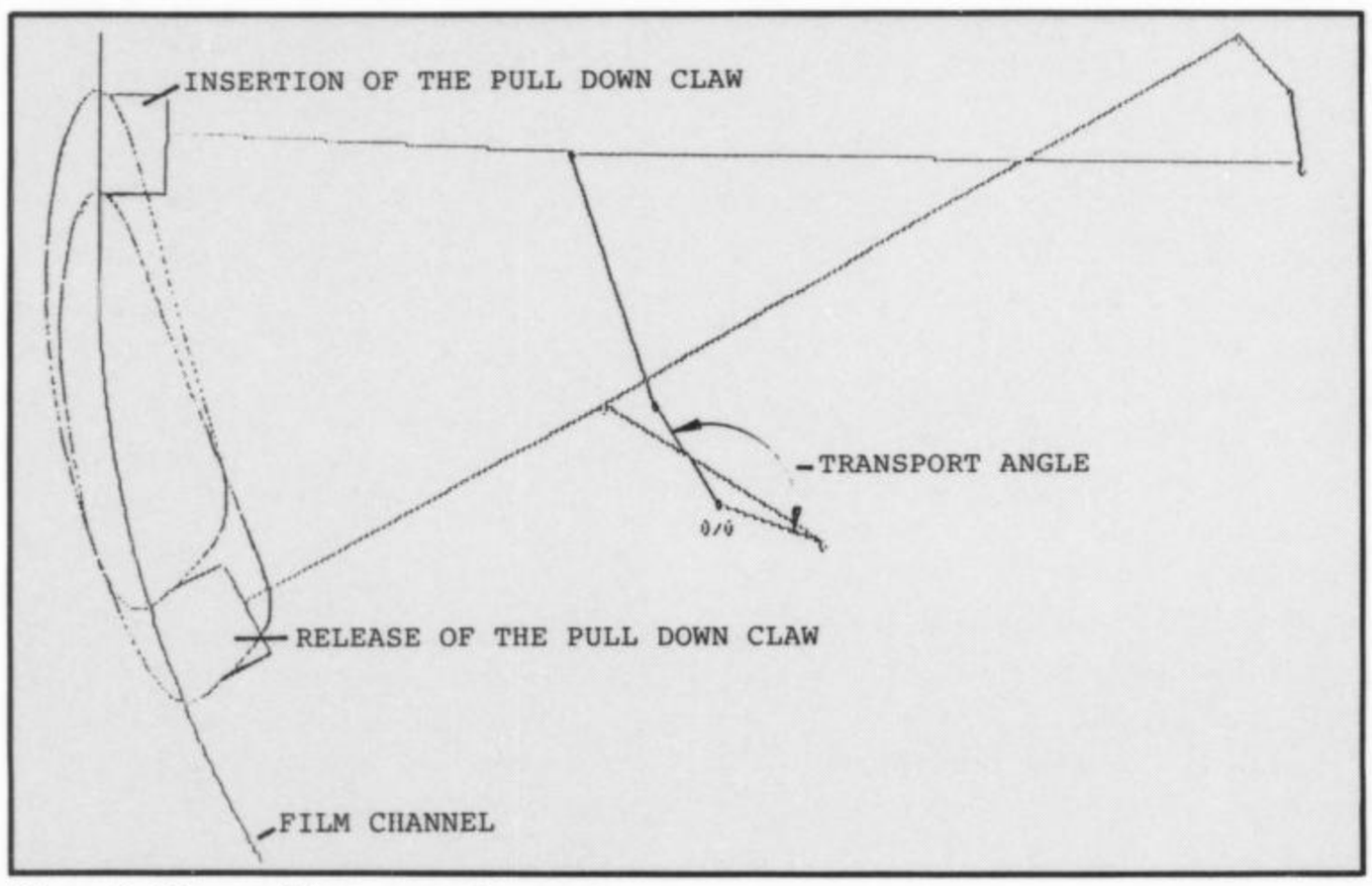


Figure 8. Claw positions, second concept.

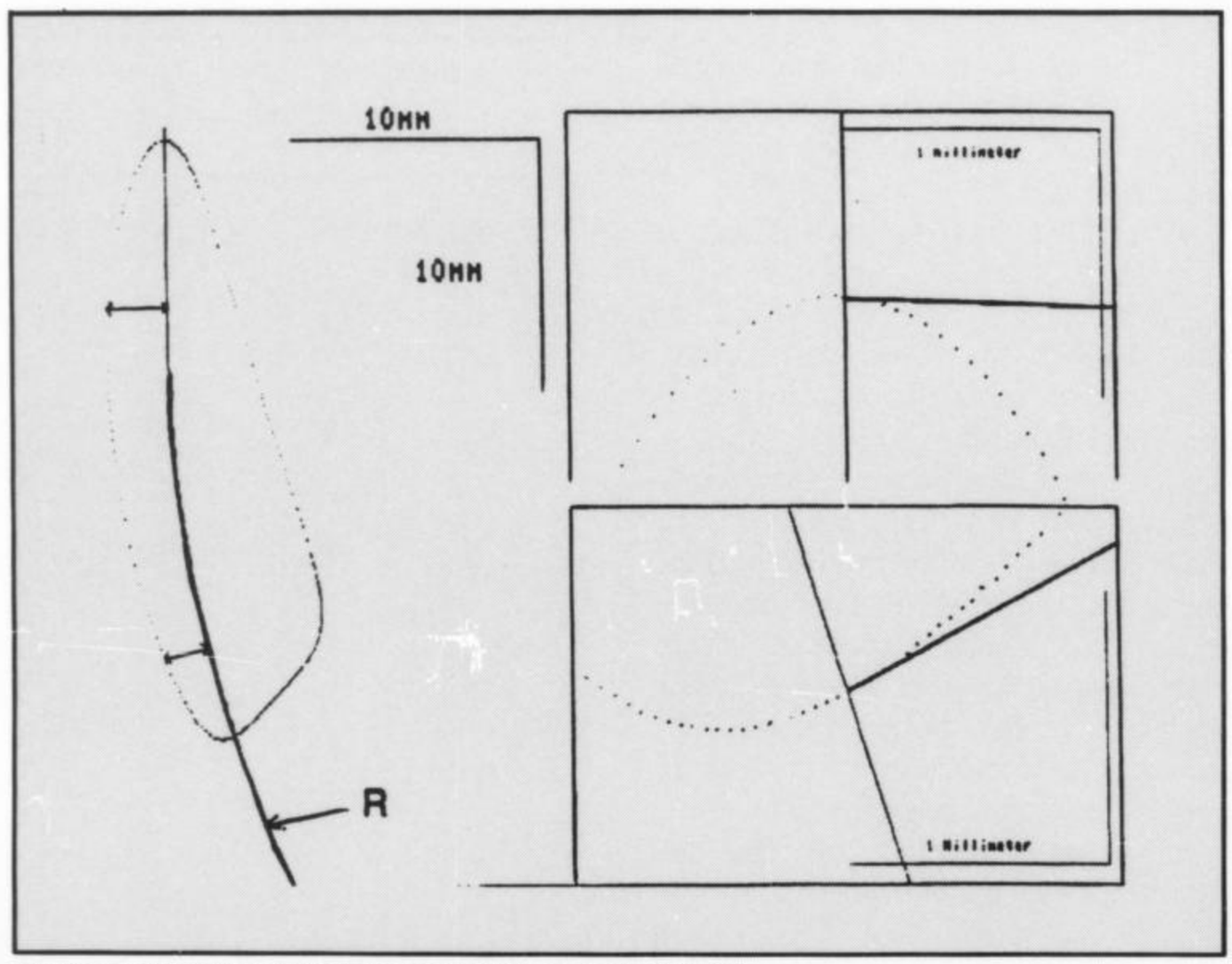


Figure 9. Insertion of the first clawpoint, second concept.

smaller bearings and by use of finite-element (FE) calculations* for the claw arm. Stability was improved by enlarging the ridge between the two bearings of the claw arm. Deformations were reduced by the improved stability resulting from the wider ridge of the claw arm. Thus the bending stress could be reduced to half its original figure.

An FE network was defined by computer to calculate the stress conditions of the finitely small elements at their discrete transition points, and the results were used to optimize the design of the claw arm (compare Fig. 11 with Fig. 12). The new claw arm is 40% lighter due to its smaller bearing dimensions (bearing eyes, cams, connecting rod) and its framework design, which has the added advantage of reducing housing vibration. Stability was improved by enlarging the ridge between the two bearing eyes, reducing deformations. The new claw arm, weighing <1 gram, is cut from aluminum and nickel-plated to improve wear characteristics.

*Finite-element calculation is a procedure by which an object is broken down into many finitely small elements to identify stress conditions as precisely as possible.

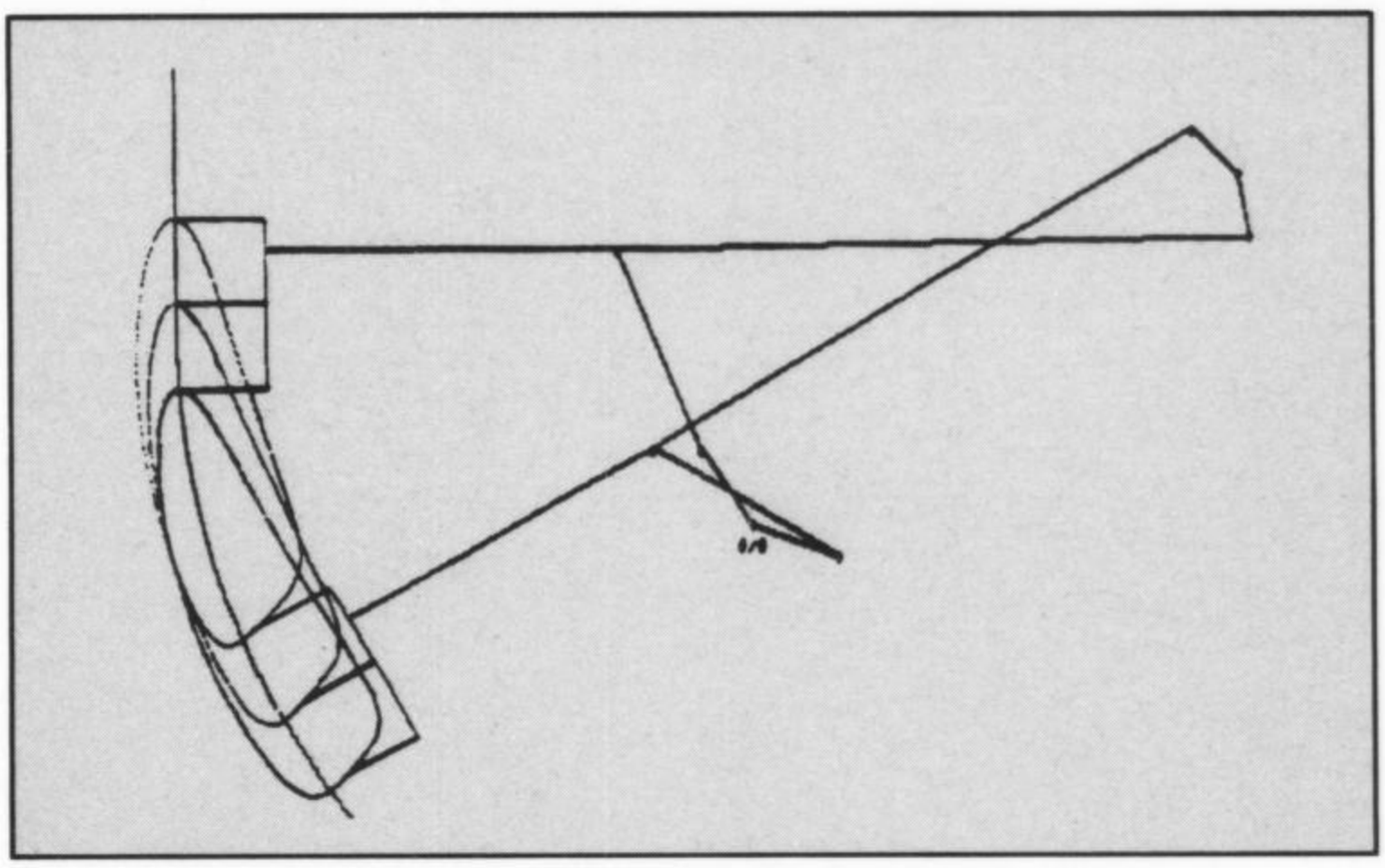


Figure 10. Paths of the three claw points, placed optimally towards the film channel.

Standard Loop Adjustment for All Frame Rates

The film loop was designed to provide a balance between the continuous (to and from the magazine) and intermittent movement (stepwise movement for exposure) of the film stock. An optimum loop is characterized by its contained, stable, and vibration-free run whose shape withstands the air resistance generated by the movement. The dynamic movement of the loop at high frame rates produces eddies in the camera. Air resistance may cause deformations and vibrations which, in turn, may produce noise, perforation damage, or breakage of the film.

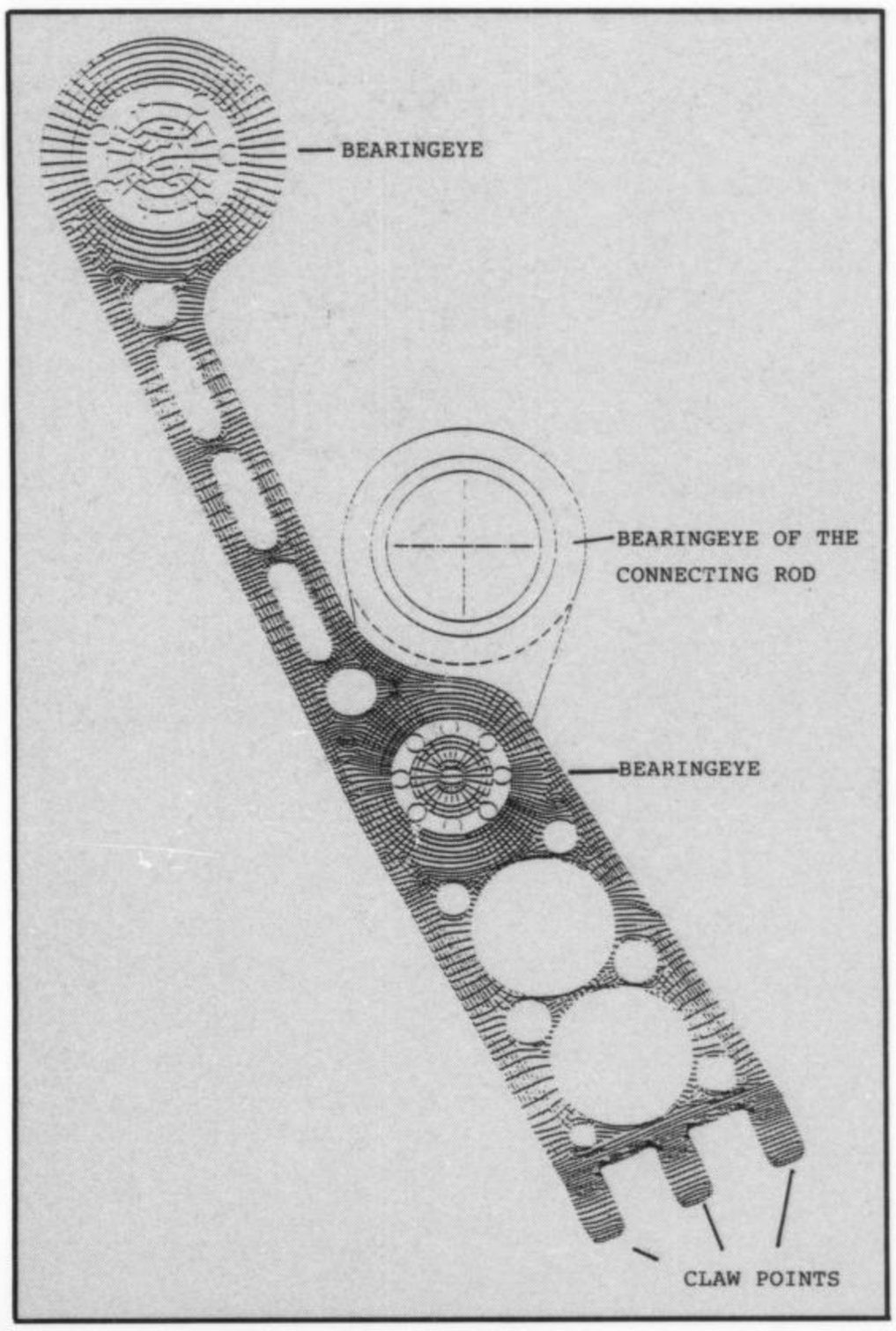


Figure 11. Initial design of the claw arm.

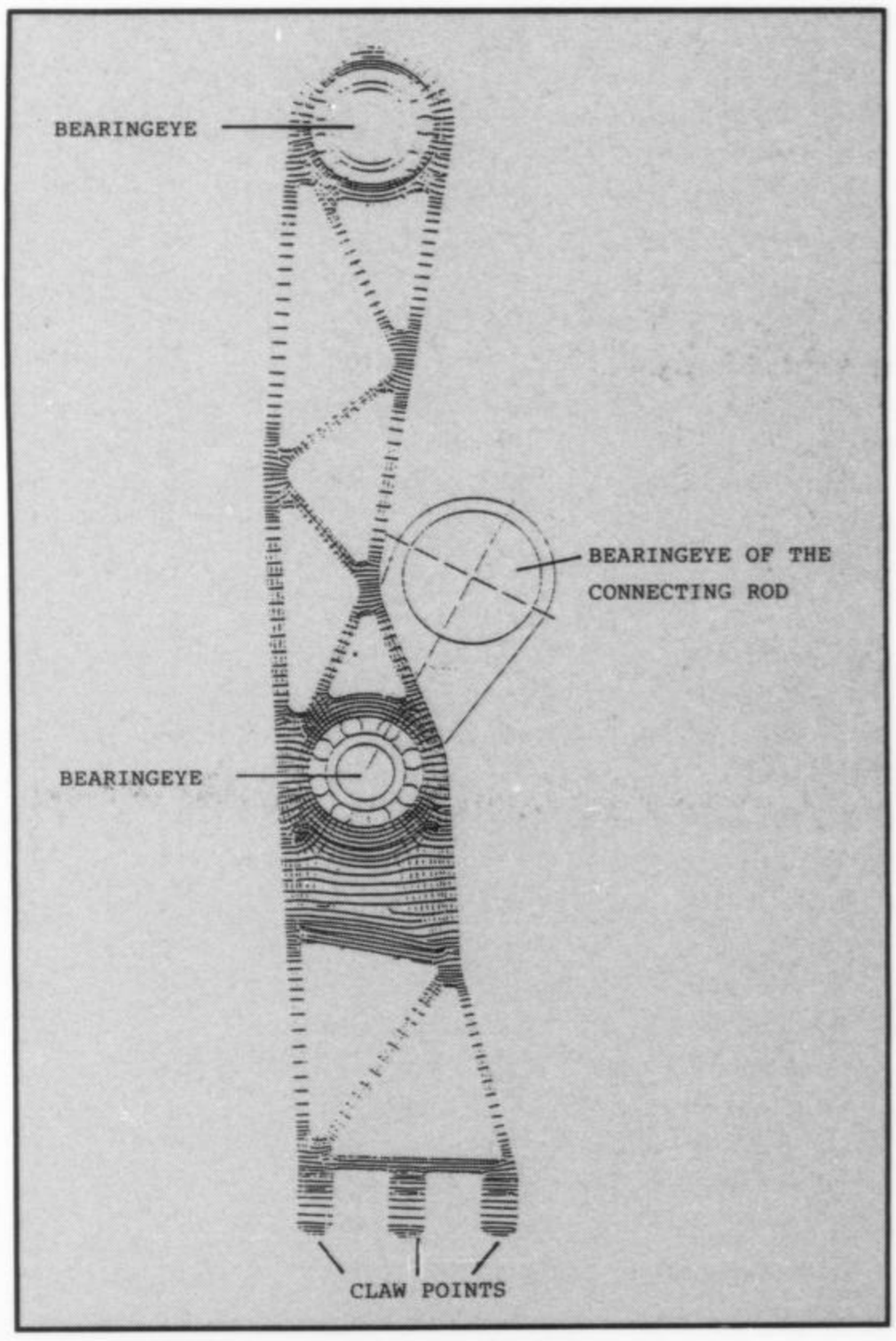


Figure 12. Optimized design of the claw arm.

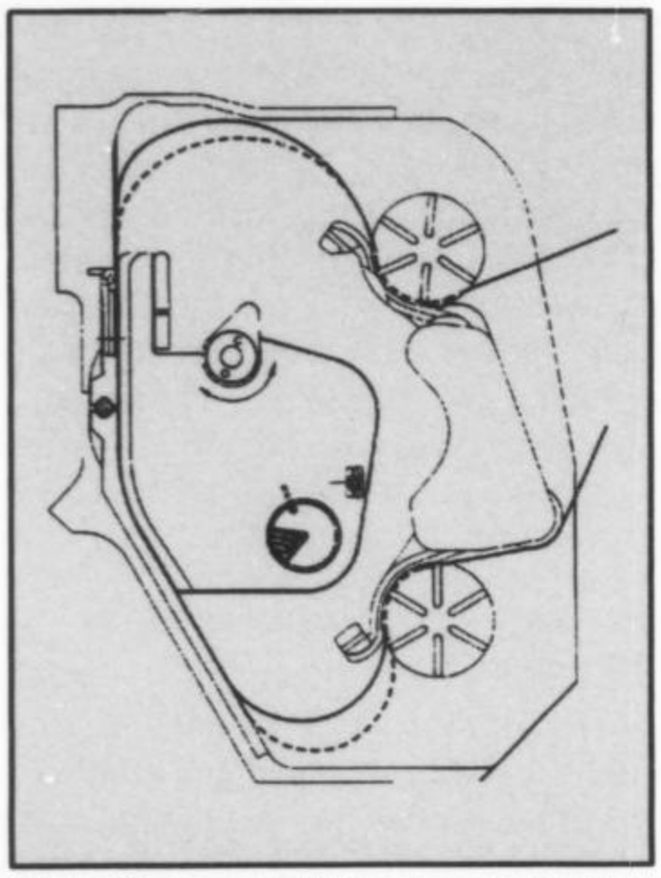


Figure 13. Upper and lower loop moving freely, side view.

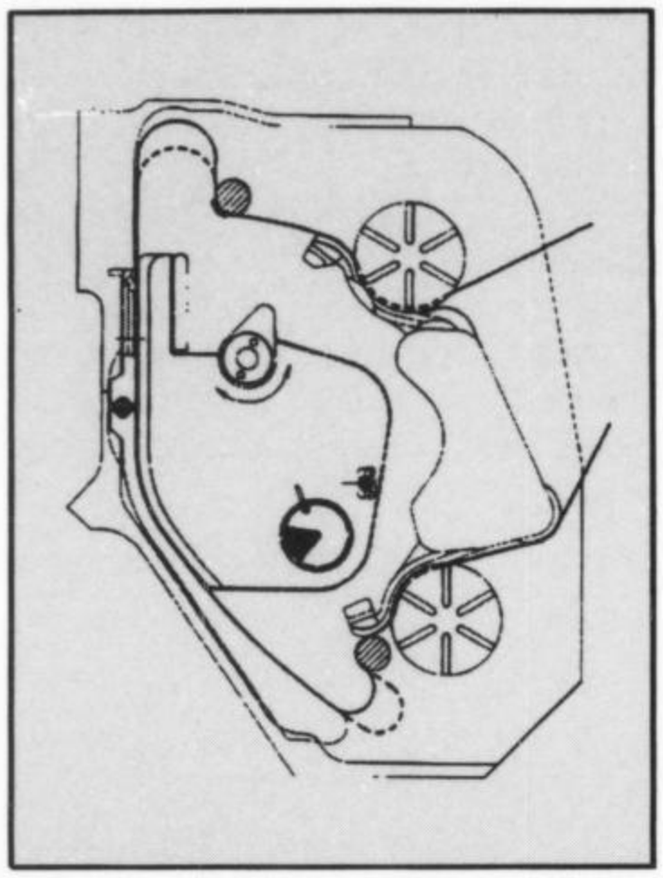


Figure 14. Shaping the film loop by idler rollers.

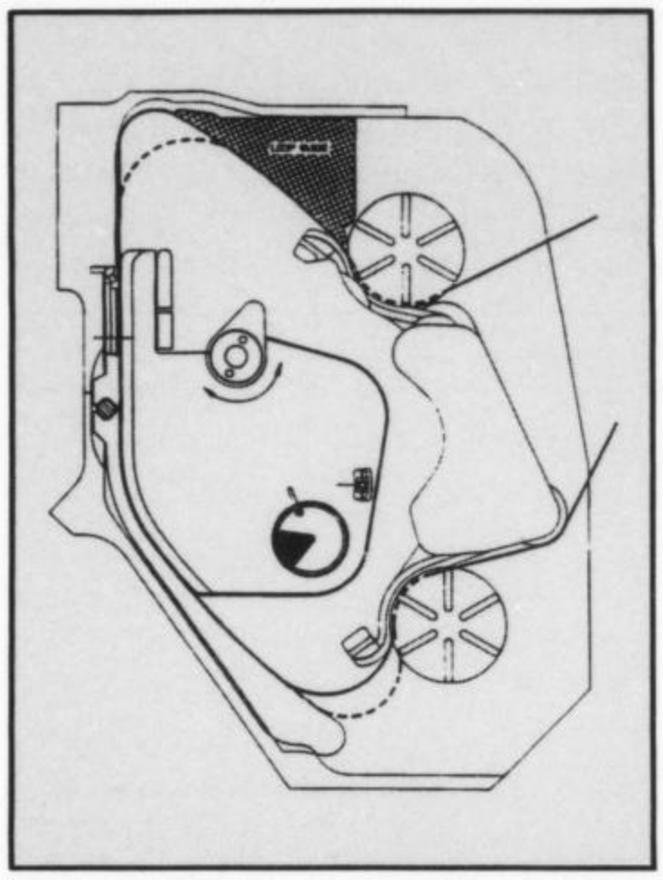


Figure 15. Film loop optimized by upper loop guide and curved lower film guide, side view.

Loop behavior was analyzed exactly, using a stroboscope, particularly with regard to high frame rates. The test setup (with the camera mounted open) permitted an examination of the causes for normal as well as impairing movements of the film loop. The insights gained from this analysis, together with numerous tests, were combined to determine the optimum single loop for all frame rates.

The internal design of this 65mm camera provided for a fixed location of the claw unit and the two sprockets, together with the reversing level for the sprocket guides, to ensure free run of the upper and lower film loops (Fig. 13). Use of two-toothed pulldown claws allowed a rate of 65 frames/sec, which fell far short of the 100 frame/sec requirement.

The best theoretical method of optimizing the film loop would have been to use one idler roller for each transport sprocket (Fig. 14). These idler rollers would have contained the loop as much as possible and given it more stability, as it would have been less affected by air resistance. This solution was rejected, however, as it would have impaired easy use of the camera and necessitated extensive redesign.

A loop guide to stabilize the upper loop and a continuous curvature of the lower guide (to stabilize the external centrifugal force) achieved a rate of 90 frames/sec with the two-toothed pulldown claws (Fig. 15). For rates over 90 frames/sec, however, problems multiplied, as the film could not withstand the forces transmitted by two pulldown-claw points, and the

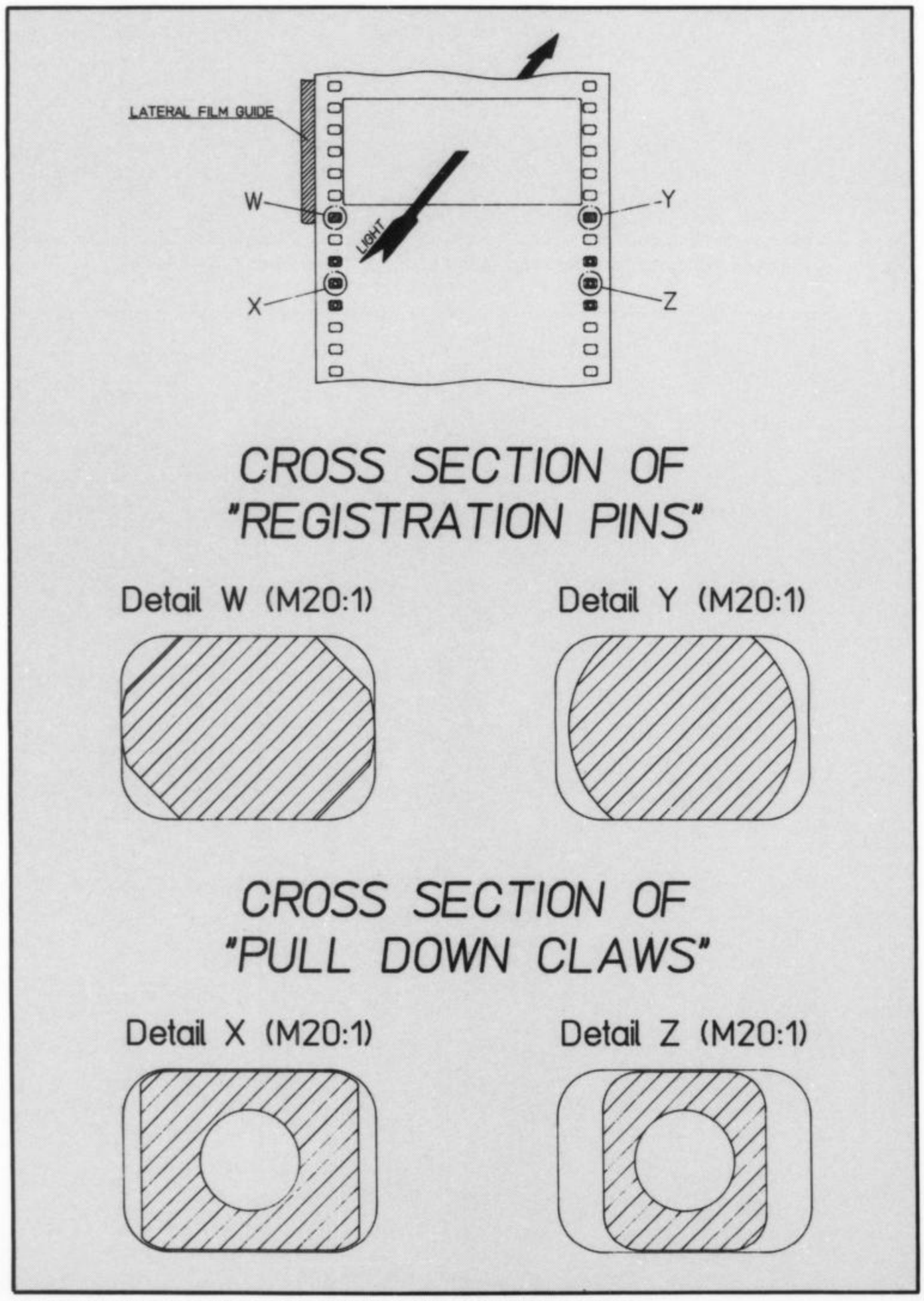


Figure 16. Cross sections of registration pins and pulldown claws.

perforation was torn. Thus a third pulldown-claw point had to be added.

The resulting pulldown-claw system (double-sided and three-toothed) moves the film smoothly at 100 frames/sec. In addition, the supporting surface of the pulldown-claw points was increased.

Picture Steadiness

Key criteria for picture steadiness at <0.1% of frame height are:

- Adequate transport angle
- Optimized claw path
- Larger supporting surface of the pulldown-claw points, optimized claw radii, and a lateral guide
- Optimized transfer between pulldown claws and registration pins (pitch adjustment)

Enlarging the Supporting Surface of the Pulldown Claw Points, Point Clearance

Acceleration acting on the film stock increases by a factor of two of the frame rate. Thus, at 100 frames/sec, the force applied to the claw system for film movement is 16 times greater than that for the standard speed of 25 frames/sec (as explained above):

25:100 frames/sec = 1.4
$4^2 = 16$

Thus, at 100 frames/sec, acceleration reaches approximately 1100 times the acceleration due to gravity (g = 9.81 m/sec^2) in the pulling phase, while deceleration reaches approximately 1300 times the acceleration due to gravity in the braking phase. An idle mass of 1.7 grams of the film loop becomes a weight of 1.87 kilopounds (kp) in the pulling phase and 2.21 kp in the braking phase for the two pulldown claws.

To ensure optimum transmission of these forces, the supporting surface of the pulldown-claw points had to be increased, in addition to adding three-toothed pulldown claws. The left-hand pulldown-claw points (as seen from the front) were enlarged so that they engage with the radii of the perforations (Fig. 16). The point radius was raised to 0.4 mm to fit the perforation radii of 0.5 mm.

Similarly, the left-hand registration-pin point had to be optimized to retain the film exactly, so that the left-hand pin moves freely only at the four radii, to reduce noise generation. The right-hand claw arm and registration pin were optimized (lateral clearance, 0.5 and 0.2 mm) so that their reduced surfaces can easily compensate for any film-stock shrinkages and ensure optimum film movement.

The lateral guide (Fig. 16) at the level of the film frame minimizes noise generated when the registration pins engage and adds stability to improve picture steadiness. Picture steadiness of ≤0.1 of the frame height (≤0.023 mm) thus depends mainly on the shape of the registration-pin points which must be optimized to fit standardized perforation.

Perforation height was standardized at 1.980 mm (±0.01 mm). The registration-pin points are 1.970 and 1.968 mm high, a tolerance range of 0.002. The camera is fitted only with registration pins whose points meet the required values. The example in Table 4 illustrates the picture steadiness achieved.

Table 4 — Example of Picture Steadiness Achieved

Most favorable case	
Lowest perforation	1.970
Largest point	1.970
Maximum clearance (mm)	0.000
Least favorable case	
Highest perforation	1.990
Smallest point	1.968
Maximum clearance (mm)	0.022

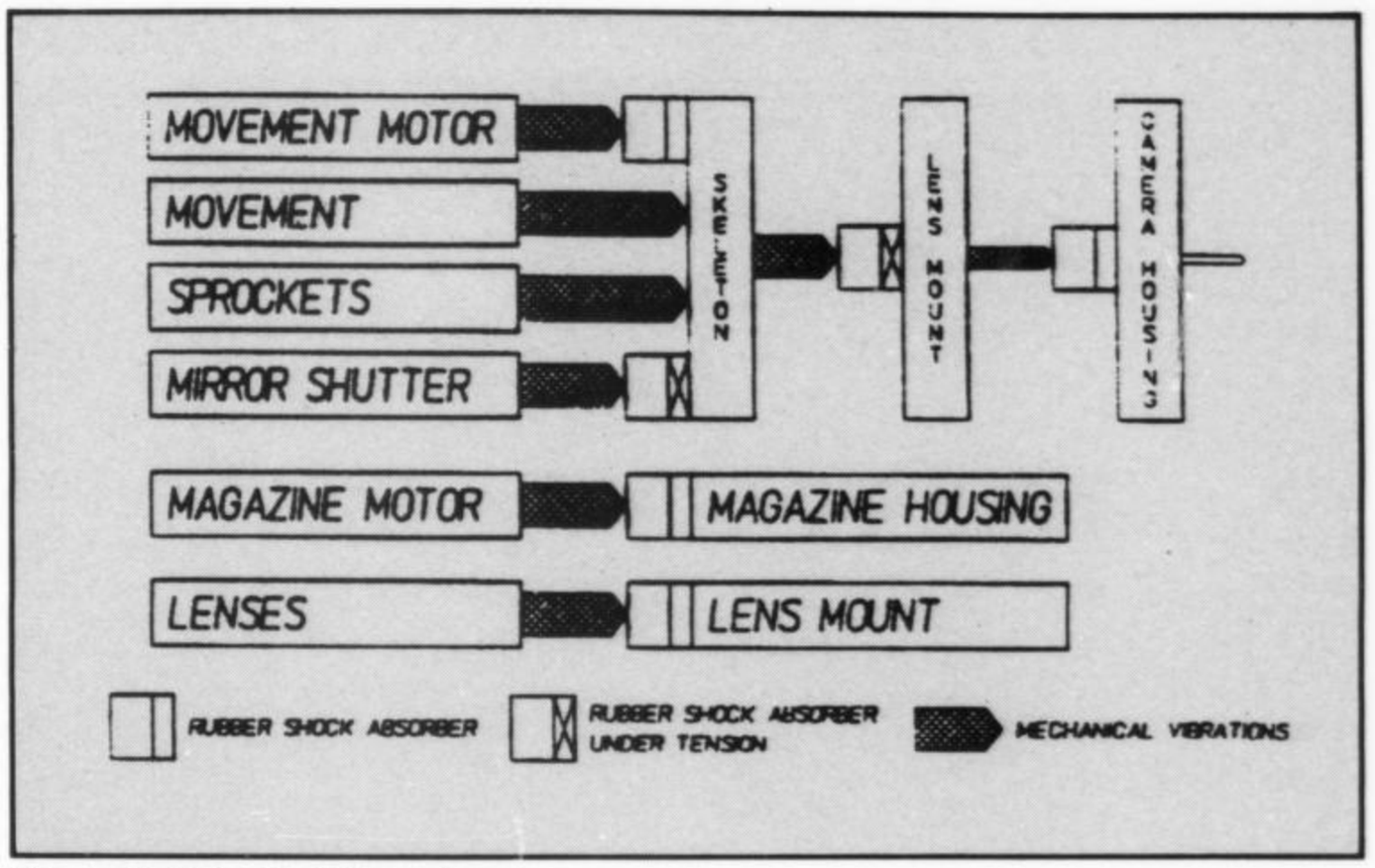


Figure 17. Noise insulation scheme.

Transfer between Pulldown Claw and Registration Pin

Optimum transfer between pulldown claw and registration pin is essential for picture steadiness as well as low noise, and must be ensured for normal as well as shrunk film. Flexible adaptation to the film stock is achieved by pitch adjustment (discussed below).

Noise Level

Reducing camera noise to ≤25 dBA at 24/25 frames/sec was possible only by combining noise-prevention with noise-minimization measures. Noise-control measures included noise insulation, pitch adjustment, and optimization of the loop guide (discussed above).

Noise Insulation

Noise insulation (Fig. 17) is designed to prevent noise at the main camera elements. The claws and transport sprockets are rigidly connected to the skeleton (inner camera) and thus transmit their structure-borne noise to the skeleton. The structure-borne noise of the main motor to the skeleton is absorbed by the frame via rubber elements. The RMS is insulated by means of pretensioned rubber elements.

The structure-borne noise of the skeleton is absorbed by pretensioned rubber elements to the lens mount. The lens mount, in turn, is connected to the camera housing through rubber

elements, and the lenses themselves are noise-insulated so that the noise carried to the external camera housing is very low. The structure-borne noise of the magazine motor is absorbed by rubber elements at the magazine housing so that little noise is carried outwards.

Pitch Adjustment

One way to minimize noise is to optimize the transfer between the pulldown claws and registration pins so that the pitch adjustment allows flexible pulldown and transfer in accordance with film requirements (Fig. 18). This pitch adjustment ensures low-noise film movement since claw insertion, transport, and release operate accurately in an optimum claw path even with shrunk film. When shrunk film is used (e.g., film shrunk by 0.01 mm/perforation pitch), insertion of the pulldown-claw points must be increased (by 0.02 mm in the example), while reducing pulldown by 0.05 mm (Fig. 19a).

In practice, the assistant cameraman adjusts the pitch during shooting (24/25 frames/sec), using an Allen key and pressing and shifting the pitch-adjust control connected to the pulldown cam (±2.5 mm upward or downward) (Fig. 19b). This pitch adjustment translates the vertical shift into a near-horizontal shift in the

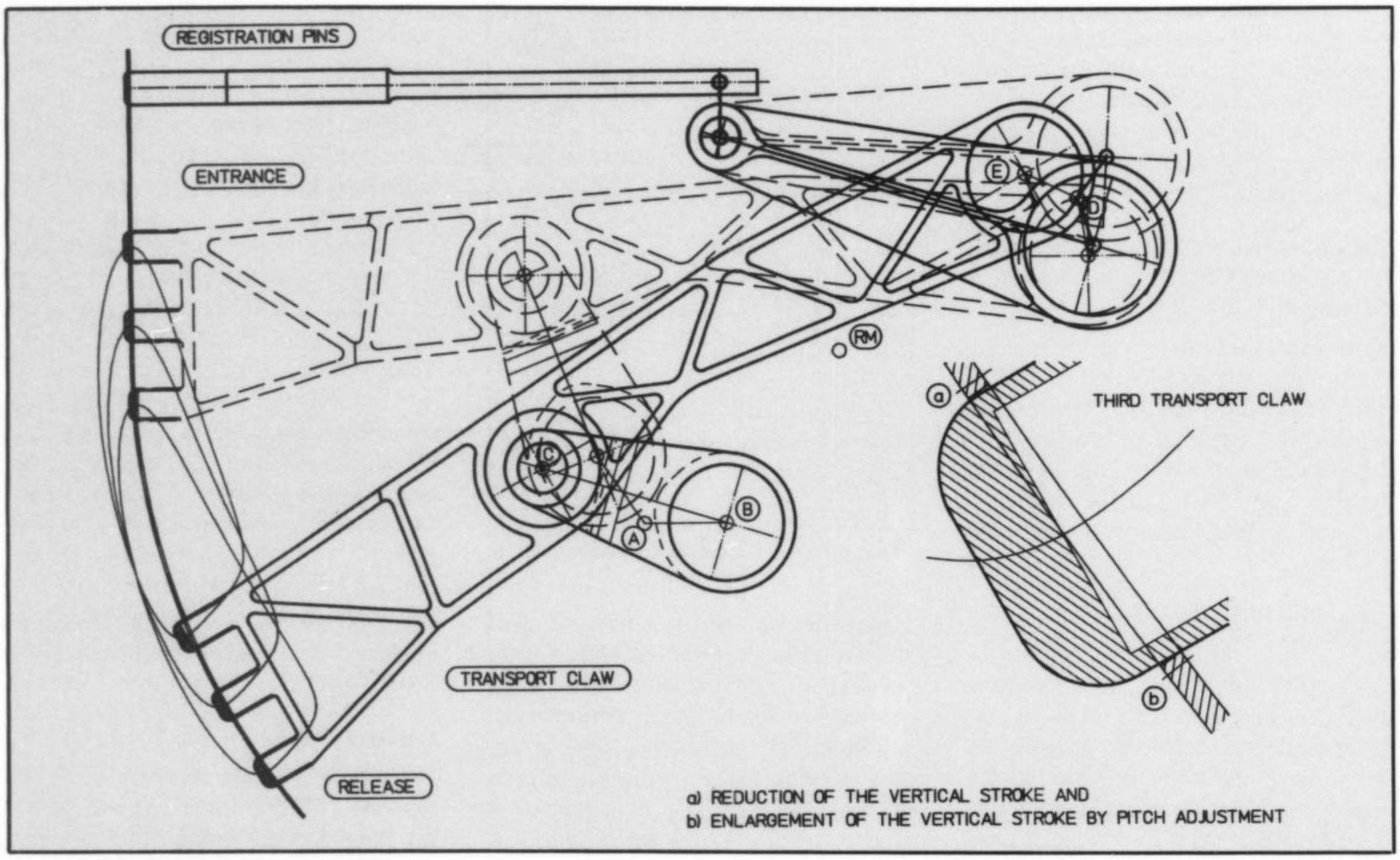


Figure 18. Optimized transport system.

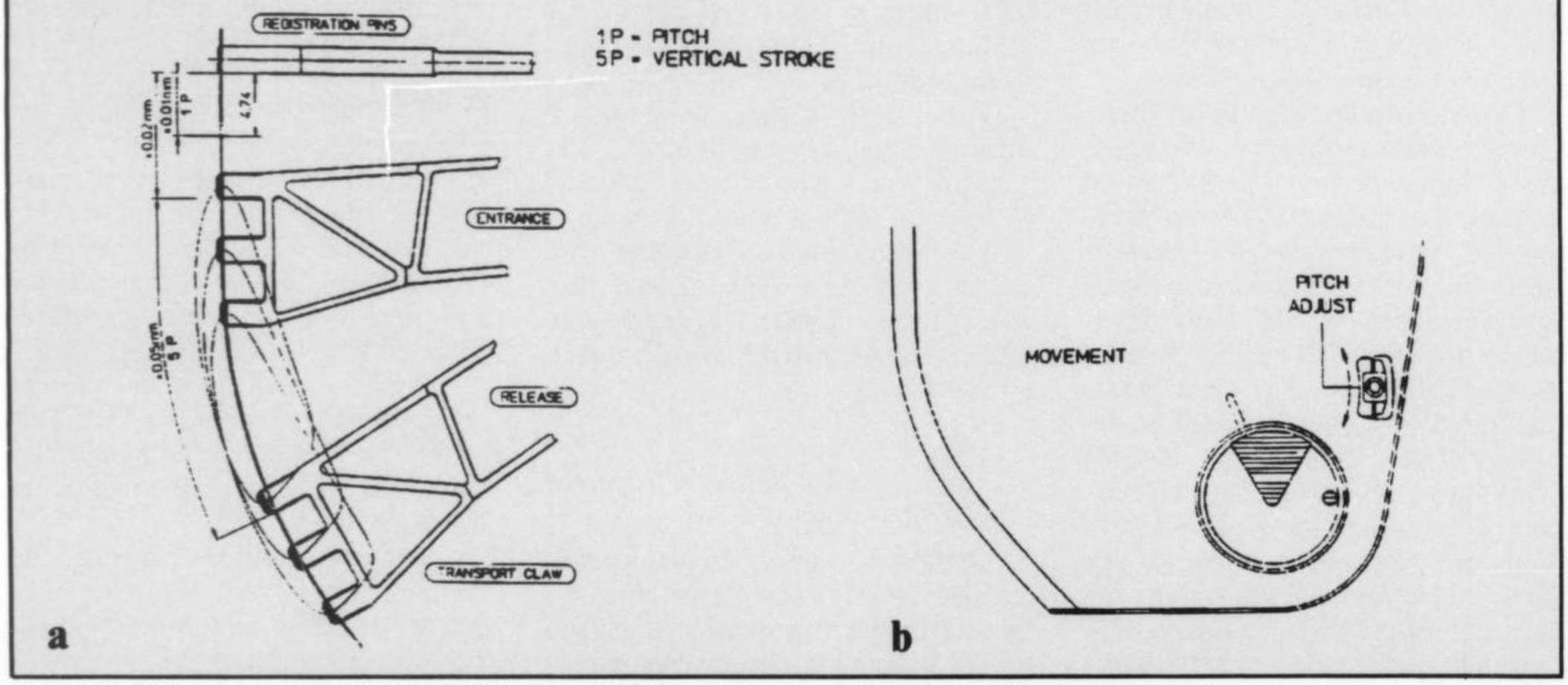


Figure 19. Pitch adjustment: (a) transfer between the pulldown claws and registration pins, side view; (b) side view.

range of some hundredths of a millimeter of the pulldown cam.

Zero Maintenance

Zero maintenance, which means user-friendliness as well, is an important factor in the development of a camera movement system. The criteria for the ARRIFLEX 765 were the use of ball bearings instead of slide bearings and compensation of thermal expansion according to the Rost principle.†

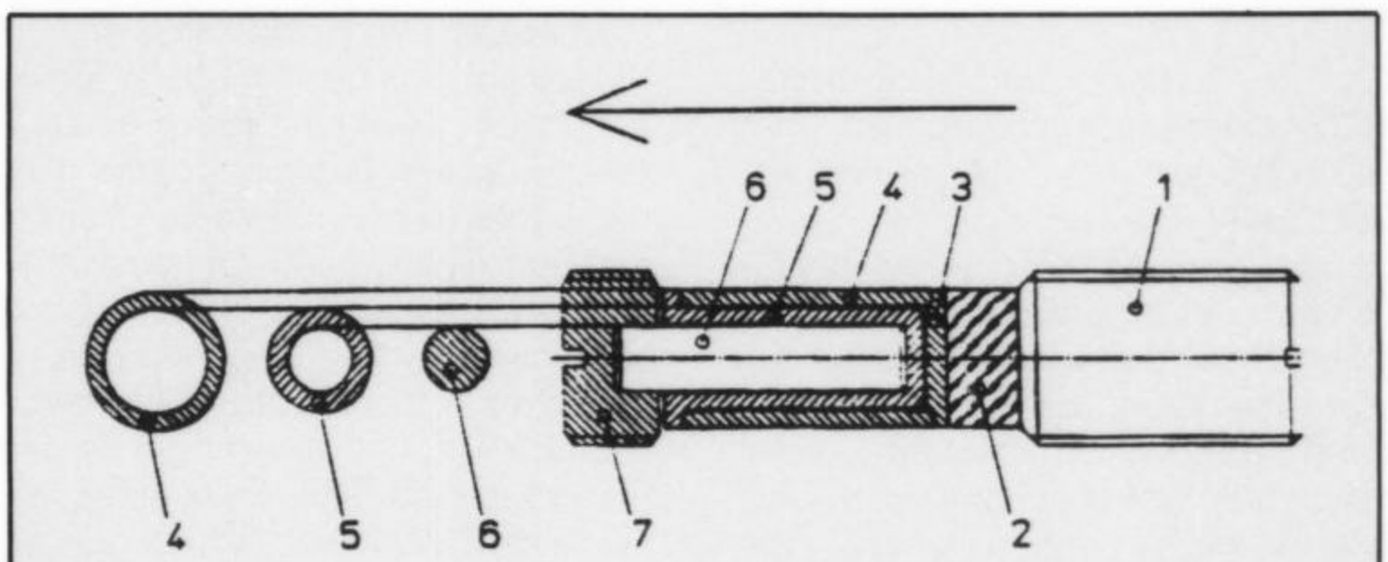
Traditional transport systems normally use slide bearings, some of which require regular greasing. The high bearing forces generated by the 65mm format and high frame rates, and the need for zero maintenance, called for a pulldown-claw design using ball bearings. As a result, the camera is maintenance-free for the duration of shooting an entire motion picture.

Application of the Rost principle for compensation of thermal expansion touches only slightly on the zero-maintenance feature. Compensation of thermal expansion ensures a constant flange focal distance at a temperature range from −20°C to +50°C, eliminating the need for readjustment (maintenance).

Two of the thermal-expansion-compensation elements illustrated in Fig. 20 are fitted in the lens mount (to the right and left of the lens mount), tensioning the rubber layer between the lens mount and the inner camera (Fig. 21). The tensioned rubber layer absorbs noise, while the tensioning elements ensure a stable connection between the lens mount and inner camera.

When the temperature rises, the sleeve (Fig. 20, no. 4) which is supported by the setscrew (1) in the inner camera via a distance plate (3) and plexiglass element (2), expands slightly in the direction of the arrow. At the same time, the intermediate sleeve (5) expands by a multiple factor in the opposite direction, thus overcompensating the expansion of sleeve (4) and pin (6) which is supported by setscrew (7) in the lens mount. Overcompensation is necessary to account for expansion of the inner camera vis-à-vis the film plane as well.

†The Rost principle is known mainly for its use in compensating thermal expansion in pendulum clocks to ensure precision timekeeping. The ARRIFLEX 765 applies the Rost principle to compensate thermal expansion in the lens mount.



1. Setscrew
2. Plexiglass element
3. Distance plate
4. Sleeve (pernifer)
5. Intermediate sleeve (aluminum)
6. Pin (pernifer — metal alloy)
7. Setscrew

Figure 20. Thermal compensation element — Rost principle.

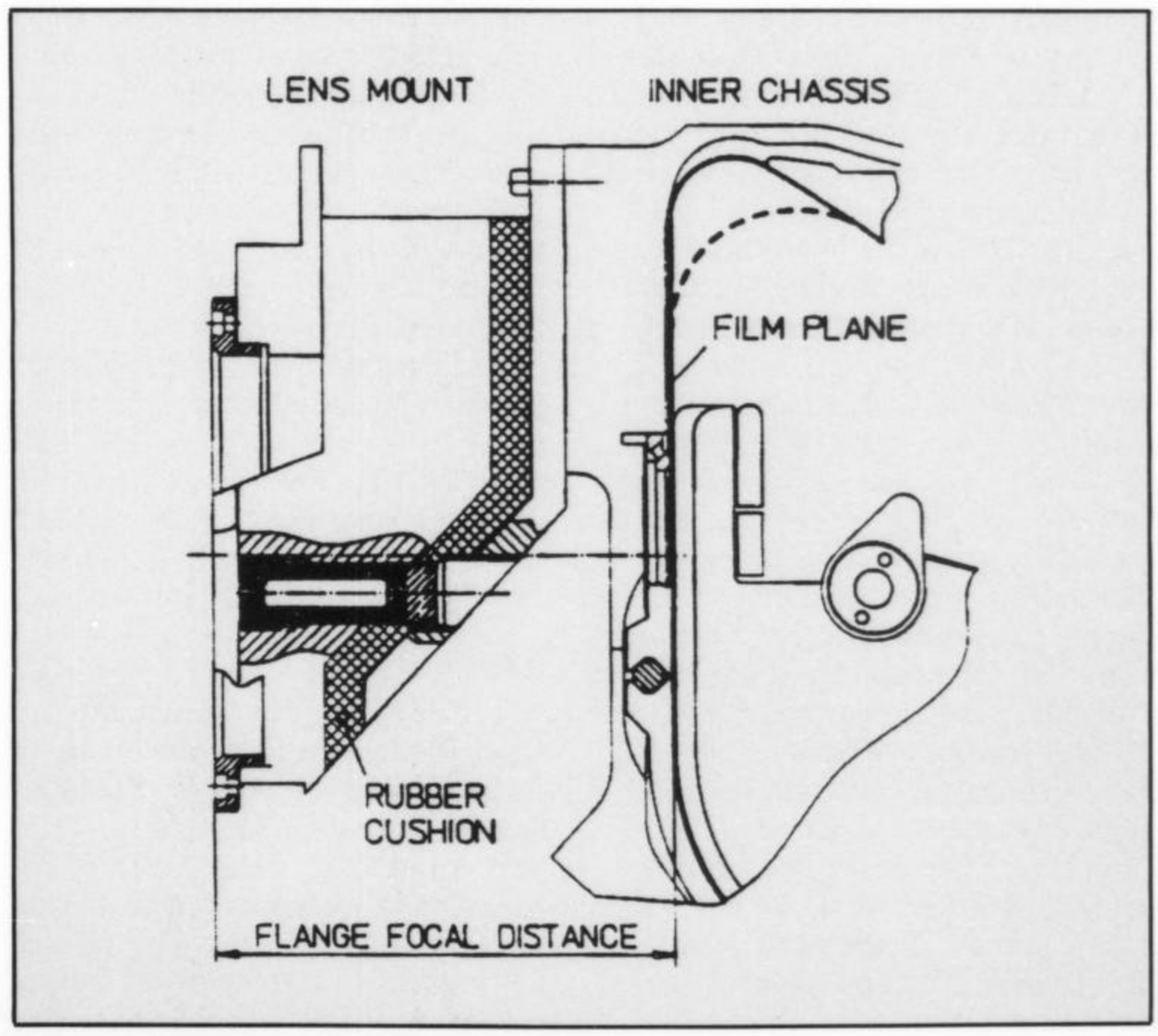


Figure 21. Compensation for thermal expansion.

Conclusion

We feel that the ARRIFLEX 765 represents the world's leading camera concept for 65mm cinematography. This camera system was specifically designed for the user ergonomics of popular 35mm motion-picture cameras, and features a noise level under 25 dBA, full reflex mirror viewing, and a maximum operating speed of 100 frames/sec.

The new system represents the last word in modern optomechanical technology and is expected to introduce a new era in cinematography for the big screen, with both shooting efficiency and excellent photographic quality. This combination should be equally attractive to producers and cinematographers of theatrical feature feature films and special venue attractions. The camera system is presented as a tool to be utilized to free the motion-picture world from the technical limitations which previously hindered 65mm production, and it is expected to significantly expand the envelope of creative possibilities available to filmmakers today.

Common Image Format for International Television Program Exchange

By Stanley N. Baron and Kerns H. Powers

A proposal is made for a set of high-definition production and international television program exchange standards that incorporate the concept of common image format (CIF), but also employ a common data rate (CDR) for recording and distribution. The issues of processing headroom, blanking transitions, and line-rate conversion to other formats and standards are examined.

Since the 1980–81 demonstrations by NHK of high-defintion television, broadcasters around the world have stated their desire for a single world standard for high-definition production and international program exchange. The possibility of consensus on a single picture-repetition rate (field or frame) for such a world standard seems to have vanished at the Plenipotentiary Meeting of the CCIR at Dubrovnik, Yugoslavia, in 1986.

Studies are now being conducted on the possibility of at least reaching agreement on a family of standards in which as many common parameters as possible (other than picture repetition rate) are specified. Such a specification would maximize commonality in television equipment designed for the 50- and 60-Hz markets and would, it is hoped, minimize the difficulties of standards conversion, now the single most crucial impediment to the international exchange of programs.

Two approaches to the standard set of parameters have been suggested:

1. A logical extension of CCIR Rec. 601, based on a common sampling frequency for all images regardless of structure or frame rate and, therefore, providing for a common data rate (CDR)
2. A system based upon a standard active-image structure having the same number of active lines per frame and active pixels per line regardless of frame rate and, therefore, providing for a common image format (CIF)

Presented at the 131st SMPTE Technical Conference in Los Angeles (paper no. 131-37) on October 22, 1989. Stanley N. Baron (who read the paper) is with National Broadcasting Co., Inc., New York, NY 10112, and Kerns H. Powers is a consultant in Princeton, NJ 08540. Copyright © 1990 by the Society of Motion Picture and Television Engineers, Inc.

The first of these alternatives, CDR, has the advantage of maximum commonality with, and simplest conversion to, the existing regional standards and offers high commonality in digital VTRs, thus possibly lowering the cost of that equipment. CIF, on the other hand, has the advantage of single-dimensional standards conversion and offers commonality of solid-state sensors, frame stores, and possibly display systems. Some believe that CIF is more likely to leave the door open to an ultimate single (possibly de facto) worldwide exchange standard.

The major disadvantage of CDR compared with CIF is that high-definition to high-definition (HD-to-HD) standards conversion in program exchange can result in spatial artifacts or reduced vertical resolution, thus violating the primary objective of higher definition. The most significant disadvantage of CIF is that for normal horizontal and vertical blanking intervals, the 60-Hz version of the set requires 20% more bandwidth than the 50-Hz version, leading to cost differentials that are not insignificant.

Both CDR and CIF approaches have their advocates, suggesting a possible compromise that incorporates both CDR and CIF characteristics into a single standard set. Such a possibility exists if the blanking intervals in the CIF system are adjusted to equalize the data rate. The resulting variation in blanking (more than twice the information capacity in the 50-Hz blanking intervals as in the 60-Hz versions) is not unreasonable, since there may exist a need in the 50-Hz part of the world for additional space in the video signal for auxiliary data channels. There have been sincere proposals for up to eight simultaneous multilingual stereophonic sound channels. Also, a requirement has been expressed for data channels for auxiliary services and digital-assist decoding data (e.g., for flicker control in the 50-Hz display). This data capacity is larger than is generally considered to be needed in North America.

Reaching agreement has been further complicated by a desire to incorporate the concept of "square pixels," that is, pixels (sample picture elements) that are equally spaced or dimensioned horizonally and vertically. The concept of square pixels has real meaning only in progressive scan (proscan) systems, since in interlace only half of the vertical pixels are present in each field. Thus pixels are near square only in stationary regions of an interlaced frame. For a production standard, however, square pixels have an advantage when image manipulations (especially rotations) are being applied. Special effects equipment must generally compensate in its software algorithms for distortions that result when images with nonsquare pixels are being manipulated.

Since progressive scan systems provide higher dynamic resolution than interlaced ones and exhibit fewer motion artifacts under scan conversion, production systems will also benefit from proscan, if means can be found to ameliorate the higher bandwidth implied. One approach to a solution has been described elsewhere.[1]

The purpose of this article is to examine the possibility of achieving a common image structure and data rate (CISDR) compromise and to explore the issues of processing headroom, blanking transitions, and line-rate conversion to other standards.

Basic Proposal

Three possible solutions for CISDR are offered (Table I) based on luminance sampling of the interlaced versions at 72.0 MHz, 74.25 MHz, and 76.5 MHz. All three are based on a common image format with square pixels, but also provide for a common data rate. The three proposals share in common the following parameters:

Table 1 — Three Choices for a CISDR Standard

	A	B	C
Y sampling rate (MHz)	72.0	74.25	76.5
Total no. lines			
59.94 Hz:	1155	1155	1155
50.0 Hz:	1250	1250	1250
Total samples line			
59.94 Hz:	2080	2145	2210
50.0 Hz:	2304	2376	2448
Vertical blanking (lines)			
59.94 Hz:	75	75	75
50.0 Hz:	170	170	170
Horizontal blanking (μsec)			
59.94 Hz:	2.2	3.0	3.8
50.0 Hz:	5.3	6.1	6.9
Common data rate (Gbits/sec)	1.152	1.188	1.224

Active matrix:	1920 (H) × 1080 (V)
Picture aspect ratio:	16:9
Scanning structure:	Interlaced (2:1), orthogonal or progressive (1:1), quincunx[1]

The other key parameters (for the interlaced version) are listed in Table 1.

The horizontal and vertical blanking intervals are rather tight for the 59.94-Hz specification and rather loose for the 50.0-Hz version, permitting space in the latter for additional data channels. The common data rates for all three alternatives are within the range of current experimental technology of digital VTRs.

Blanking Transition Considerations

The 1920 × 1080 active pixel structure for the CISDR approach just described is a direct extension of CCIR Rec. 601 to a widescreen high-definition production standard with square pixels. A precise definition of the boundaries of the "active image," however, is desired to assure headroom needed for post-production processing and standards conversion. There appears to be a consensus among digital video experts that some edge headroom for processing alias and the avoidance of ringing of digital filters at the edges of the image demand a controlled blanking transition waveform, not only in the horizontal dimension but in the vertical as well. Otherwise, cropping of the processing "edge effects" might be required in the release formats.

The shoot-and-protect philosophy implied in the selection of the 16:9 aspect ratio (AR) for electronic production can be beneficial in assuring processing headroom, particularly in aspect-ratio conversions. The preference for the value of 16:9 derives from its flexibility and compatibility with existing film-release ratios. Figure 1 illustrates the concept of shoot-and-protect as applied to the 16:9 choice. If the action is framed to be contained within the inner reticle (with aspect ratio of 1.77) and if spurious intrusions, such as microphones, lighting fixtures, dolly tracks, or other production paraphernalia, are excluded from the region between the reticle and the outer aperture (also 1.77 AR), then images of all ratios between 1.33 and 2.35 can be framed with their boundaries lying within the shaded protection zone.

In contrast with other shoot-and-protect methods that are currently used in widescreen film production to protect 4:3 TV releases, the 16:9 approach allows both the action reticle and the aperture to be in widescreen format. The adoption of square pixels in the CISDR standard permits the reticle and the various release images to be specified and measured, simply, in numbers of pixels H × V. If the outer aperture represents 1920 × 1080 pixels, the action reticle becomes 1440 × 810. A 4:3 image is obtained by extending the reticle to top and bottom; thus it becomes 1440 × 1080. Similarly, the CinemaScope 2.35 is derived by extending the reticle horizontally to the aperture boundaries; thus it becomes 1920 × 816. All other aspect ratios in the range of 1.33 to 2.35 can be derived by framing the appropriate image within the protection zone to suit the aesthetic goals of the artistic director or cinematographer.

Obviously, if the tenet of shoot-and-protect is adhered to in high-definition electronic production (HDEP) cinematography, there should be adequate margin on all four sides of the image for processing headroom and for moderate cropping in format conversions.

In the NTSC implementation of CCIR Rec. 601, the 720 active pixels are assigned as follows:[2]

708	for the widest analog active period (100 IRE possible)
6	for the line-blanking transition pulses
6	for tolerances in the blanking period and for alias margin
720	

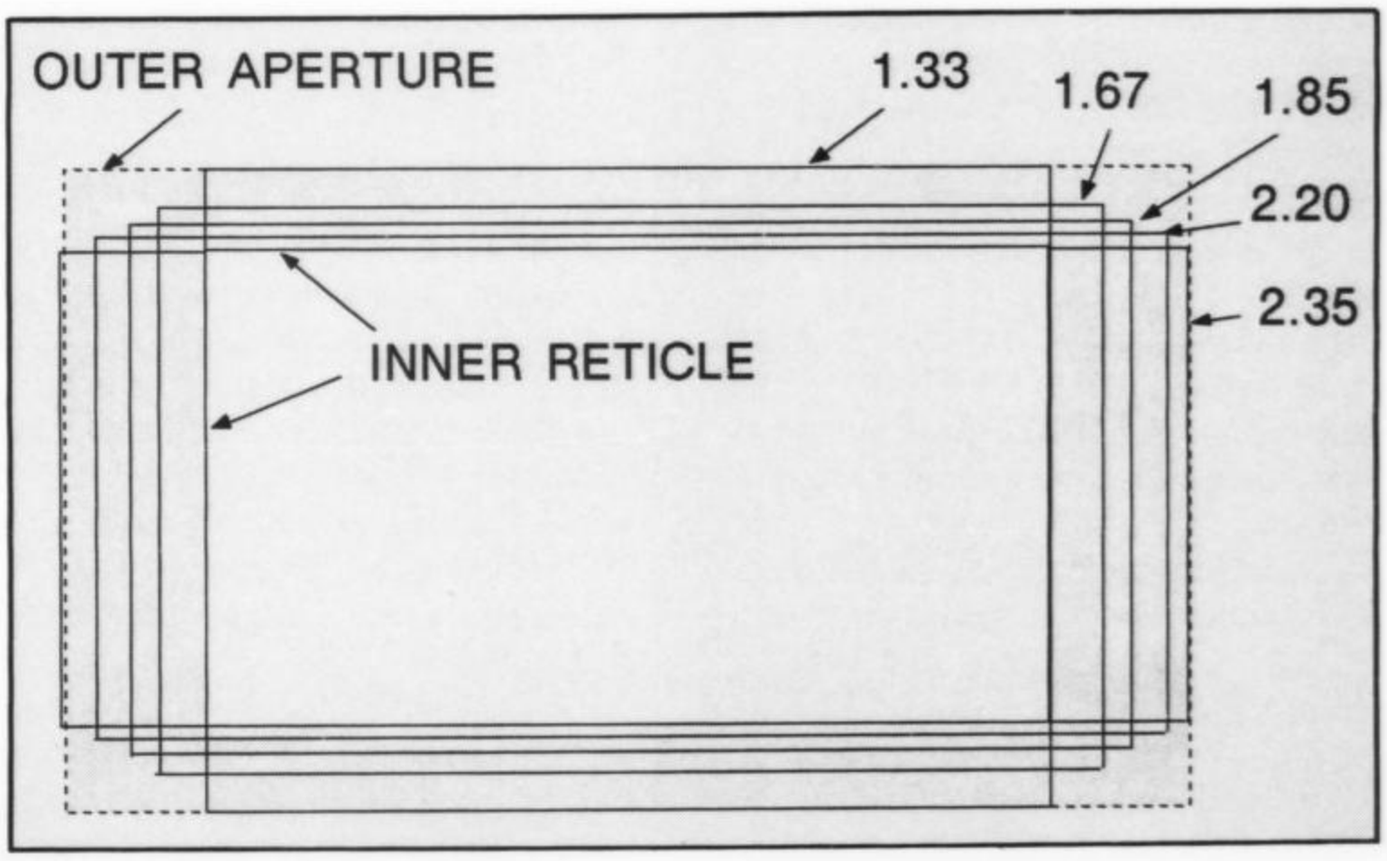


Figure 1. Shoot-and-protect at 16:9.

In the 625-line implementation, even fewer pixels are reserved for the widest analog active period. However, we need not model the HDEP standard on the same set of assumptions on which CCIR Rec. 601 was modeled, since we are dealing with fewer compromises between the 59.94- and 50-Hz versions of the standard so the tolerances for digital implementation can be tighter.

The following assignments are suggested for the CISDR specification of 1920 active horizontal pixels:

1910	for the widest analog full active period
8	4 pixels at each end for blanking transition
2	1 pixel at each end to accommodate alias margin
1920	

Figure 2 illustrates a case in which four sample periods on each side of the image constitute the horizontal transition wave. The "line-blanking pulse," as defined in CCIR documentation, is a transition curve that provides a spatial fade-to-black at the edges of the image. It is applied as a multiplier to the luminance and chrominance values of the image, having the value of 1.0 during the active picture and the value of 0 during the blanking interval.

The transition from 1.0 to 0 should be a smooth S-shaped curve spread over a few sample periods in the digital video format. The active line could conceivably be measured from either of three positions along the transition wave. In analog systems, the traditional measurement is made at the "50% point" (of a white field), or the point at which the transition wave has a value of 0.5. This measurement can be made only in the absence of picture content and is thus customarily made on a "white field." In digital systems, one could measure also from the "last unprocessed picture sample" (the last fully white sample in a white field, or the limits of 100 IRE luminance values) or alternatively from "the first fully black blanking sample."

Measurements of aspect ratio can be rendered equal at all three of these measurement points by choosing the number of sample periods in the horizontal blanking transition equal to the number of line periods in the vertical transition multiplied by the aspect ratio. However, as long as the blanking transitions are of short duration, a ratio near 16:9 is close enough. An even number of transition periods in both horizontal and vertical directions will guarantee a sample point with a value of 0.5 at the center of all transitions.

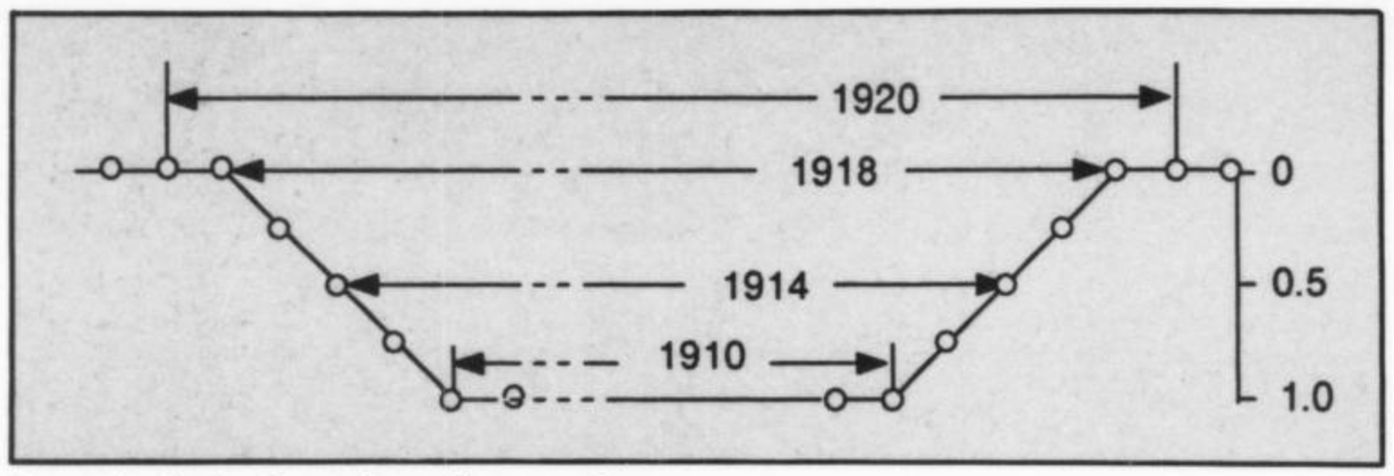


Figure 2. The horizontal transition waveform.

In the vertical dimension, we suggest the following:

1074	for the widest active frame
4	2 lines each at top and bottom for transition
2	1 line at top and bottom for aliasing margin
1080	

Thus if 1920 × 1080 is assumed to include the entire transition waveforms, measurements of aspect ratio taken at the three points of measurements on the transitions compared with the precise value are

$$\frac{1920}{1080} = 1.777778 \quad \text{(total active frame)}$$

$$\frac{1918}{1078} = 1.779221 \quad \text{(first black sample)}$$

$$\frac{1914}{1076} = 1.77881 \quad \text{(50\% point)}$$

$$\frac{1910}{1074} = 1.77840 \quad \text{(last white sample)}$$

which are all sufficiently close to 16:9 for practical purposes. The provision of more transition samples in horizontal than in vertical is reasonable since digital filters in the horizontal dimension are likely to be more complex (have more coefficients) than those in the vertical because of the higher cost of line stores over latches. More complex filters with sharper cutoff will, of course, be more susceptible to edge ringing.

The errors in the measurements of picture aspect ratio given above could also be interpreted as slight deviation from pixel squareness, if the picture aspect ratio is assumed to be precise. Either intepretation is valid and both yield insignificant errors.

Line-Rate Conversion

The frame-rate conversion (which will not be discussed in this article) between 50- and 59.94-Hz versions of the CISDR standard is, of course, a critical issue that is not unique to the question of CIF versus CDR standard selection. Line-rate conversion, on the other hand, is an issue with CIF, even though none is required for program exchange purposes. Under the assumption that HDTV emission standards compatible with the existing 625/50 and 525/59.94 systems will likely be adopted in both 50- and 59.94-Hz countries, line-rate conversion from the CIF exchange standard to the appropriate compatible studio standard must be considered. Thus we need to examine high-definition to high-definition line-rate conversion from 1080 active lines to both 1152 and 968 active lines while, we hope, minimizing edge effects, picture cropping, and image distortions. Conversions to 625/50 and 525/59.94 are, of course, best obtained by 2:1 low-pass filtering and subsampling from the 1152 or 968 active-line standard at the appropriate (possibly converted) frame rate.

In a previous article,[3] the complexity advantages of time-varying parabolic interpolation over theoretical and classical linear (time invariant) filtering techniques have been discussed. The advantages are particularly important for line-rate conversion because only three lines of storage and three multipliers are required. To minimize the complexity of the line-rate converter, however, it is often desirable to crop or distort the image (squeeze or stretch) to obtain a small integer fraction for the conversion ratio.

For conversion from 1080 to 968 active lines (including transitions), the exact nonreducible conversion ratio is:

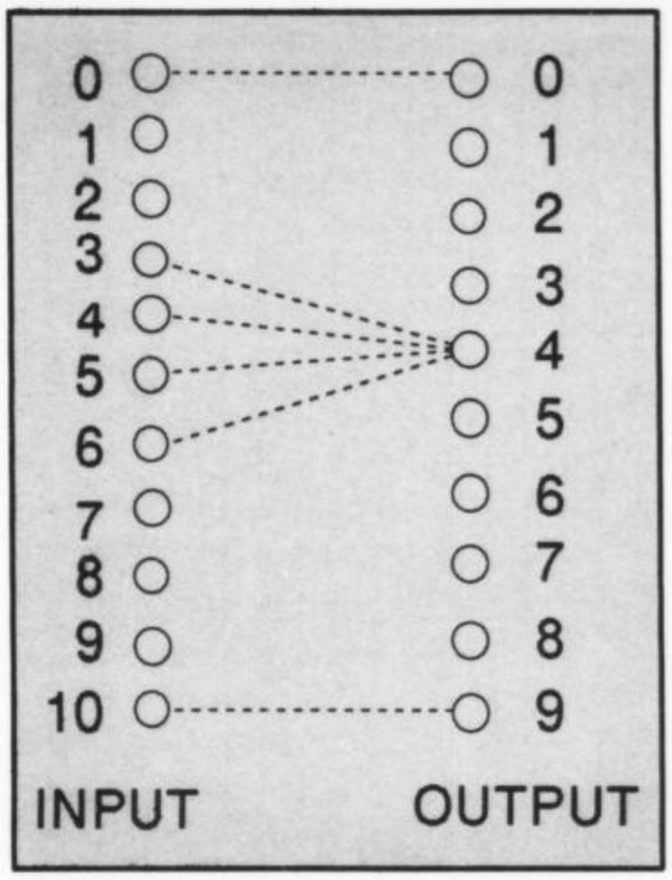


Figure 3. Sample positions in each of 108 blocks.

$$\frac{1080}{968} = \frac{135}{121}$$

which would require the storage of 363 multiplier coefficients in a read-only memory (ROM), even using the optimized parabolic interpolation technique. This figure, however, is very close to the factor

$$\frac{1080}{972} = \frac{10}{9}$$

the use of which will reduce to 27 the number of coefficients in ROM storage. The interpolation is performed over 108 blocks of 10 samples (lines) each in original standard, interpolated to 9 samples (lines) in the new standard. The positions of the samples in each block are shown in Fig. 3.

The input and output lines at the top and bottom of each block are coincident and used directly (without interpolation). Since each interpolated line (interior to the block) is derived by weighting the sample values from the two original lines on either side of it, there is no "end-point" effect at the ends of each block. Thus information from only 1080 lines of the original (CISDR) standard are used in the interpolation process. No interpolation "edge effect" will therefore occur at the top and bottom of the image. However, since 972 converted lines are obtained instead of the 968 desired, 4 lines (2 each at the top and bottom) are discarded at the time of conversion to the emission standard. The vertical blanking transition lines are cropped, and the image is thereby stretched vertically by a 0.4% factor, well below the threshold of perception. It would be advantageous to leave the extra lines in the production format, however, so that downconversion to 525 will have some extra headroom for vertical filtering edge effects.

The conversion from 1080 to 972 active lines involves decimation and thus the danger of adding aliasing to the image. If the source image came from a camera or telecine, the only presample filtering that has been applied are the modulation transfer functions (MTFs) of the optics and the scanning beam spot aperture. For a solid-state imager (e.g., CCD) prefiltering occurs when the light is spatially averaged over each pixel aperture. All of these prefiltering operations are characterized by a slow roll-off MTF. Thus some aliasing would be expected to occur at parts of the image where resolution is near or above the Nyquist limit. In fact, vertical aperture correction (a post-sampling filter) no doubt enhances such aliasing, as it enhances interline flicker in an interlaced standard. It has often been said that some aliasing is beneficial, and cameras are occasionally focused with the aid of aliasing in a test-pattern wedge placed in the scene. The 10% decimation in the 1080 to 972 active-line conversion should not create an enormous alias problem, and the heroic efforts that would be required to prevent it (up-interpolation to 1944 lines and 2:1 down-filtering) are probably not worth the investment.

The operation of the four-sample interpolator illustrated in Fig. 3 is described in the referenced article.[3] In that article, a four-point optimized parabolic interpolation algorithm is described in which four successive input samples are weighted by three coefficients and summed to obtain the estimated output sample. Three multiplier coefficients are stored in ROM for each of the nine positions of the output lines in the interpolation block. Since the multipliers are digital, these coefficients (which are fractions of 81) would be rounded off to the nearest fraction with a power-of-two denominator, corresponding to the number of bits available in the multiplier. After the samples are combined in the adders and multipliers, an additional round-off will occur as the interpolated sample value is expressed in the appropriate number of output bits. Thus there will be an accumulated round-off error that constitutes a correlated noise or interpolation error. The accuracy of this four-sample parabolic interpolation method compared with the more complex linear filtering methods can be ascertained only from subjective tests.

For conversion from 1080 active lines to 1152, three favorable factors come into play. First, the upconversion will create no added alias problems. Second, the exact conversion ratio

$$\frac{1080}{1152} = \frac{15}{16}$$

is a sufficiently small-integer ratio that neither picture distortion nor cropping needs to be considered. Third, the power-of-two denominator provides multiplier coefficients that are fractions of 256, thus no round-off error will be experienced if the coefficients are used in an 8-bit or higher multiplier. If the parabolic interpolation method will pass the subjective test in the conversion to 1050/59.94, it will exceed that quality in spatial conversion to 1250/50.

Conversions to 525/59.94 and 625/50 are best accomplished by conversions first to 972 and 1152, respectively, and then down-filtering and subsampling by the factor 2:1. It is, of course, tacitly assumed that all of these conversions are done in proscan form. After the 525/59.94 and 625/50 signals are obtained in proscan form, they can be further subsampled by 2:1 (temporally interleaved) to create the interlaced versions.

Conclusion

The common image format standard with a sample grid of 1920 × 1080 active pixels has been evaluated from the standpoint of processing headroom, blanking transitions, square pixels, and line-rate conversion to other standards. By a judicious adjustment of the blanking intervals for the 50- and 59.94-Hz versions of the standard, a common data rate is also achieved. There do not appear to be any significant technical barriers to the choice of a CISDR standard for international program exchange. The political barriers have not been examined.

References

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2. CCIR Recommendation 656: Interfaces for Digital Component Video Signals in 525-line and 625-line Television Systems, *CCIR Green Books*, *11*:346–358, 1986.
3. K. H. Powers, "HDTV Standards Considerations for Electronic Cinematography and Post-Production," *SMPTE J.*, *91*:1153–1157, Dec. 1982.

Reduction of Multipath Effects and Channel Distortion in Broadcast Television

By Melih Pazarci

A new technique for the adaptive recursive removal of ghosts, using look-up and decision-based adaptive assignment of the parameters of the recursive algorithm, is described. A coarse channel estimation is used to select the initial parameter set. The algorithm requires a training signal in the vertical blanking interval. A master control algorithm keeps track of the echo-channel and system parameters and makes the necessary control decisions and echo assignments. Two-axis synchronous detection is used, and the echo-reduction operation is performed in the baseband. The system is targeted for digital NTSC and improved/extended/high-definition televison (IDTV/EDTV/HDTV) receivers and is primarily intended for use in the reception of terrestrial VHF/UHF distribution.

The multipath problem in broadcast television remains a major source of picture degradation. Propagation of the TV signal over different paths of unequal lengths from the transmitter to the receiver manifests itself as ghosts superimposed on the main picture on the screen.[1,2] Recent improvements in picture quality and the emergence of advanced TV systems necessitate an immediate solution to this problem.

A multipath reception example is given in Fig. 1. The physical structures in the broadcast area cause reflections that result in propagation over multiple paths, from the transmitter to the receiver, as shown in the figure. The loci of constant path delays, or constant propagation times, are ellipses, so that the transmitter and the receiver are located at the foci of these ellipses.

Inherently, an echo channel has a finite impulse response (FIR) due to its feedforward structure. Hence its inverse is an all-pole infinite impulse response (IIR) structure. It is possible to obtain a FIR approximation to this IIR structure; however, this approach results in a large number of filter taps. The true inverse response provides a minimal number of taps, but this true inversion is not desirable, in many cases, because of picture degradation due to noise enhancement and stability considerations.

Currently, the need exists for an echo-cancelling structure and algorithm that are optimal in number of taps, performance, and convergence speed. Such a system is described in this article.

System Description

The echo/distortion-reduction processor (EDRP) is an all-digital subsystem located between the video demodulator and the conventional *Y-C* video processing, as illustrated in the simplified block diagram (Fig. 2). Since the echo channel modifies the signal in the modulated radio frequency (RF) format, two-axis (complex) synchronous demodulation is necessary for subsequent echo cancellation in the baseband.[2,3] The carrier recovery circuit extracts the intermediate frequency (IF) picture carrier from the IF signal for use in the synchronous detector. After demodulation, the inphase and quadrature components are digitized in the analog-to-digital (A/D) converter(s).

The EDRP subsystem input is the digitized complex-baseband composite video signal including the horizontal interval, and the output is the processed composite-baseband digital video data corresponding to the active portion of the lines only. The digital video processing block includes all processing functions between the EDRP output and the display unit. To prevent hardware duplication and provide overall optimization, integration of the *Y-C* separation with the EDRP is advisable.

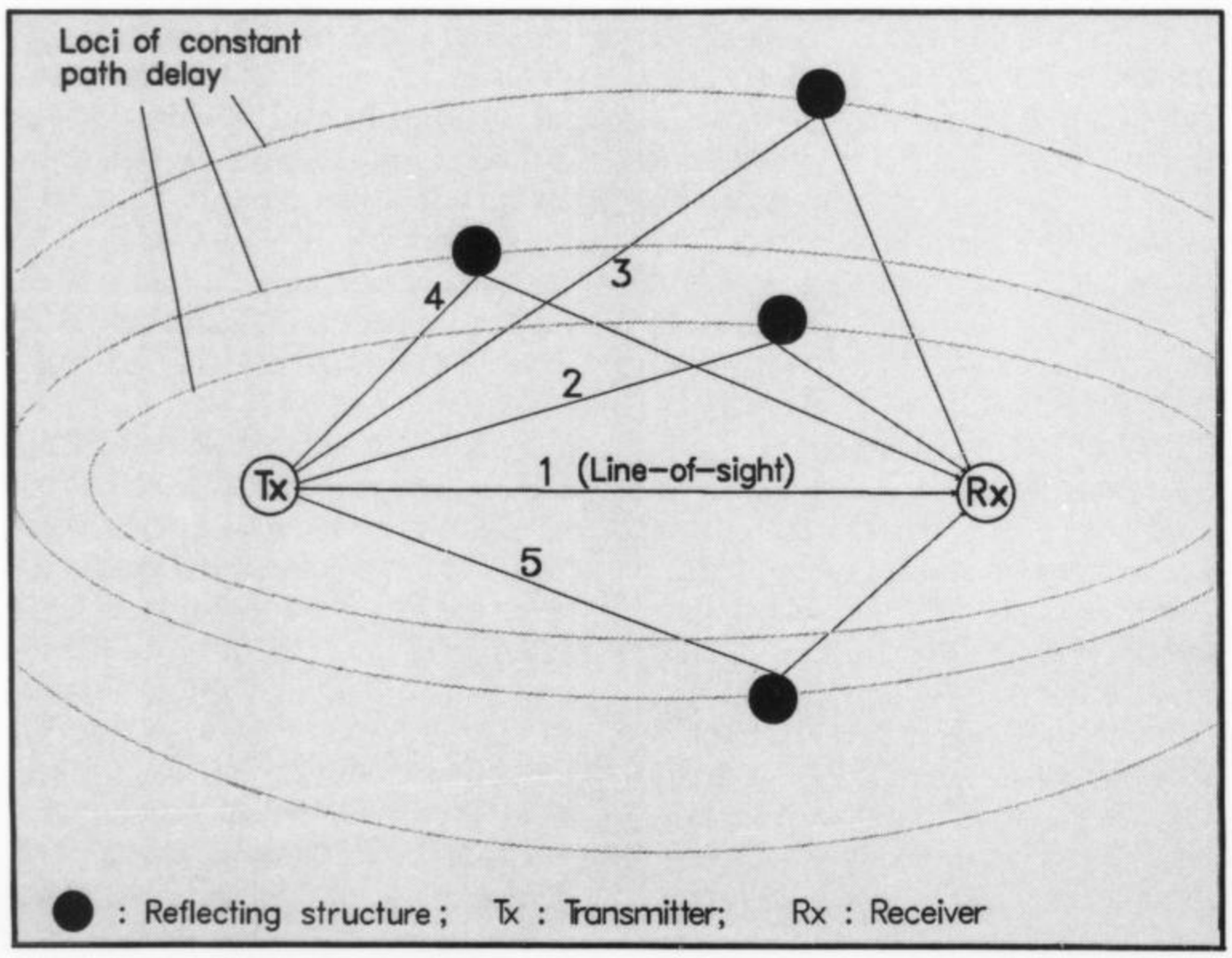

Figure 1. A multipath environment.

Presented at the 23rd Annual SMPTE Television Conference in San Francisco (paper no. 23-14) on February 3, 1989. Melih Pazarci was with the Illinois Institute of Technology, Telecommunications Systems Center, Chicago, Ill., at the time of the presentation. He is now with the Technical University of Istanbul (ITÜ), Electrical Engineering Faculty, Ayazağa, Istanbul 80626, Turkey. An unedited version appears in *Better Video Images*, SMPTE, 1989. Copyright © 1990 by the Society of Motion Picture and Television Engineers, Inc.

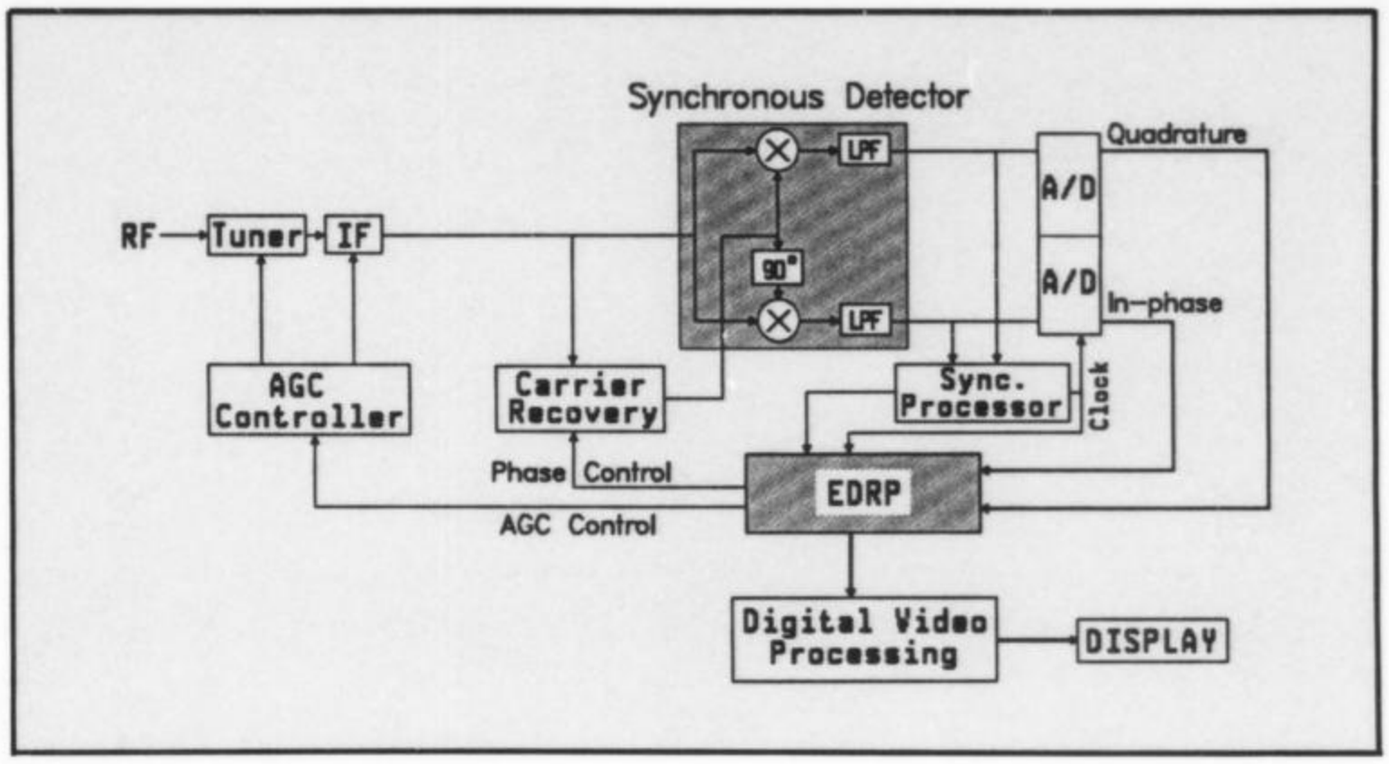

Figure 2. System block diagram.

The synchronization processor provides the system clock and other necessary timing functions in addition to its conventional duties. The EDRP has an output to control the demodulating carrier phase (for optimum detection angle), and another output to control the RF/IF automatic-gain-control (AGC) loop. The phase-control and AGC loops through the EDRP are slow so that they do not interfere with the adaptive algorithm convergence. These two controls inject an optimizing offset into their respective loops, and their control ranges are kept relatively narrow compared to the main AGC and carrier-recovery loops.

Due to its all-digital structure, the integration of the EDRP with digital TV sets will be relatively easy. For conventional and existing TV sets, the EDRP can be in the form of an external black box with an antenna input, and an analog composite baseband or modulated RF output. The incremental cost, however, will be significantly higher than in new digital sets. If echo-free simultaneous recording of another channel is desired, an EDRP subsystem must also be placed in the videocassette recorder. For EDTV/HDTV systems, the basic structure depicted in Fig. 2 may need to be modified, depending on the particular signal and distribution standards.

Reference Signal

The EDRP requires a training waveform, similar to those of other reported ghost cancellers, for proper operation. Currently, a 2*T* pulse on an unused line in the vertical blanking interval is utilized. This line used for system training is referred to as the vertical interval test line (VITL). Other reference waveforms can also be used. The reference signal selected must be of finite duration and have a single auto-correlation peak. It must also be transmittable through the TV channel with a low distortion. The 2T pulse is one of the shortest autocorrelation-width signals among those that are transmittable with low distortion, and it is well known in the broadcast community as a test waveform. Therefore, it is selected as the initial reference.

The system can be converted for operation with a different training signal by changing the data in the reference and system read-only memories (ROMs). More than one set of reference data can be stored in the ROMs if reception of VITLs of different standards is expected. In this case, the EDRP program code must include a VITL identification segment in its initialization routine to select the proper reference and system data.

In a two-channel compatible HDTV scheme, each NTSC channel must have its own VITL signal. In this case, the two transmitted VITLs can also serve in the correction of differential errors resulting from the utilization of two separate propagation paths and corresponding separate signal-processing blocks associated with the two different channels.

It must be noted that the EDRP can correct a signal only up to the point of reference insertion. Thus, the VITL must be placed as early as possible in the processing chain at the composite format level. If a received signal is degraded by multipath, and a retransmission over a different multipath channel or a nonlinear operation (such as frequency translation, demodulation, FM modulation) is to follow, VITL stripping and reinsertion are required at the EDRP-equipped intermediate receiving node.

EDRP Subsystem

A simplified block diagram of the EDRP subsystem is shown in Fig. 3. The primary components of the echo canceller are the programmable filter and the echo-distortion (ED) processor, which controls the filter.

The ED processor computes the filter coefficients and selects the filter configuration during the time interval between two consecutive VITL transmissions, based on received data, stored reference data, and programmed rules. It then loads the results into the programmable filter during the vertical blanking interval. The time period between two VITL transmissions sets the maximum available time interval for one block iteration of the adaptive algorithm. Although the total adaptation time can be significantly reduced by increasing the number of allowed iterations between two consecutive VITL transmissions, this results in increased noise sensitivity and poor channel tracking, and is therefore not recommended.

While the ED processor is computing a new set of coefficient and configuration data, the programmable filter

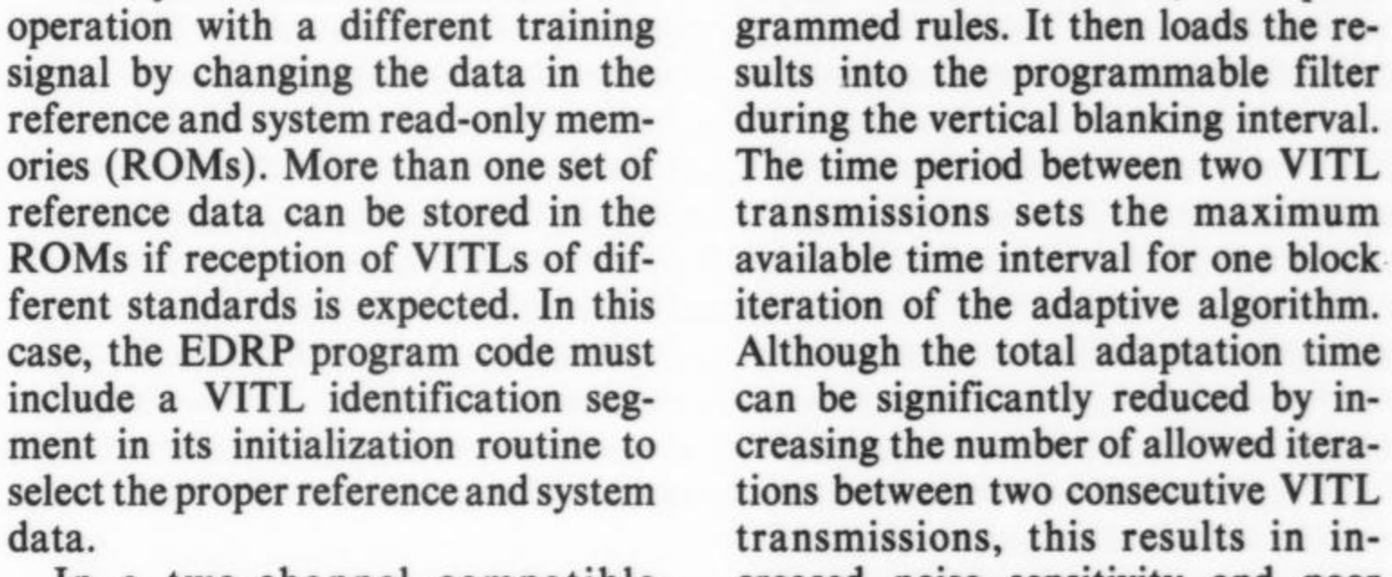

Figure 3. EDRP block diagram.

processes the incoming video data stream, including the horizontal interval data, in real time. The adaptive and system-control algorithm codes reside in the system ROM. The reference ROM contains the data for the reference waveform(s). System upgrades are possible by changing the two ROM chips. The integration of these two ROM chips with the main-code ROM of the digital TV chip set can be considered for possible cost-saving.

The VITL random-access memory (RAM) can store the complex VITL video data in real time, upon request by the processor, based on the line-timing data provided by the synchronization processor.

Adaptive Algorithm

The EDRP algorithm is a significantly modified and enhanced version of the simple hyperstable adaptive recursive filter (SHARF) algorithm. The linear part of the algorithm operations is identical to that of the original SHARF.[4-6]

If the received and digitized VITL signal is denoted as $x(k)$ in discrete time, the programmable filter output $y(k)$ is given by the following difference equation:

$$y(k) = \sum_{i=1}^{N} a_i y(k-i) + \sum_{j=0}^{M} b_j x(k-j) \quad (1)$$

where a_i and b_j are the feedback and feedforward coefficients, respectively; N and M denote the filter lengths of feedback and feedforward sections; and i and j are dummy variables. The ED processor also computes $y(k)$ as given in Eq. 1, but in nonreal time, simulating the programmable filter operation. The error sequence $e(k)$ is formed as:

$$e(k) = d(k) - y(k) \quad (2)$$

where $d(k)$ is the stored reference, i.e., the desired output.

In SHARF, this error is further filtered to obtain the modified error sequence $q(k)$, as:

$$q(k) = \sum_{i=0}^{P-1} c_i e(k-i) \quad (3)$$

where c_i are the error filter impulse response coefficients, and $c_0 = 1$.

In the enhanced version of SHARF, referred to as ISHARF, this error filtering is no longer as important for most cases. The coefficient update operation is given by:

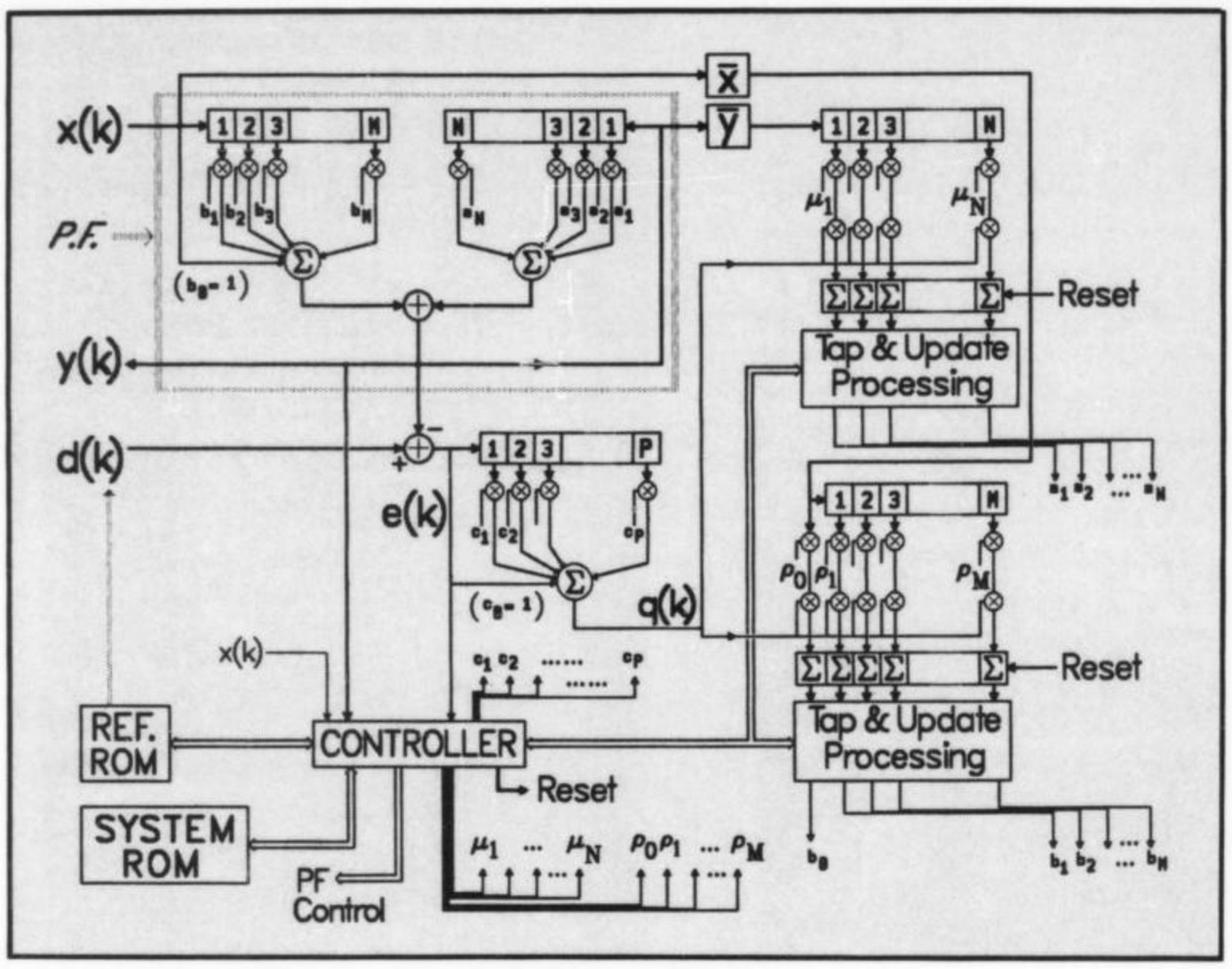

Figure 4. ED processor functional equivalent block diagram.

$$a_i(k+1) = a_i(k) + \mu q(k)\bar{y}(k-i), \quad i = 1 \rightarrow N \quad (4)$$

and

$$b_j(k+1) = b_j(k) + \rho q(k)\bar{x}(k-j), \quad j = 0 \rightarrow M \quad (5)$$

where k is the pixel iteration index, and μ and ρ are the adaptation gain constants, respectively. $\bar{x}(k)$ and $\bar{y}(k)$ denote the complex conjugates of $x(k)$ and $y(k)$. In the ED processor, the updates are done in a block mode, where the block lengths are the current sizes of the feedback and feedforward coefficient arrays, respectively. The block mode updates are given by:

$$a_i(1) = a_i(l-1) + \sum_{k=0}^{N} \mu q(k)\bar{y}(k-i), \quad i = 1 \rightarrow N \quad (6)$$

and

$$b_j(1) = b_j(l-1) + \sum_{k=0}^{N} \rho q(k)\bar{x}(k-j), \quad j = 0 \rightarrow N \quad (7)$$

where 1 is the block iteration index, and N and M are made equal for convenience, without loss of generality. This mode of operation with linear updating is termed Mode 0. In this mode, the block and pixel iteration methods will give identical results at instants corresponding to integer multiples of N input data samples. With block iterations, the update terms are accumulated for N pixels, and the taps are updated only once per VITL. Note in Eqs. 1–7 (that define the original SHARF algorithm) that if the error-filtering step in Eq. 3 is removed (i.e., $c_i = 0$ for $0 < i\,P$), and if the feedback coefficients, a_i, are forced to zero, then the algorithm will be reduced to the classical least-mean-square (LMS) method.

Figure 4 illustrates the functionally equivalent block diagram for the ED processor, where the ISHARF algorithm is implemented. The input is the digitized received VITL data, $x(k)$, from the VITL RAM. $d(k)$ is the selected stored reference data from the reference ROM. $y(k)$ is the processed VITL output for internal computational use of the algorithm. The sub-block, that is shade-outlined and identified as PF, is the section that simulates the external real-time programmable filter hardware. This non-real-time simulation of the programmable filter within the adaptive algorithm implementation makes the real-time hardware and adaptive algorithm independent from each other in operation. The ED processor outputs are the programmable filter tap values ($a_1, \ldots a_N$, and $b_0, \ldots b_M$) and the configuration-control data identified as the PF Control in Fig. 4.

In ISHARF, the μ and ρ adaptive gains are functions of the particular tap and the current iteration (i.e., state of convergence). The feedback gain, μ_i, has a higher priority than ρ_i in coefficient assignment. The update

gains have descending numerical values (if nonzero) for increasing echo delay. Although a total of $2N$ filter coefficient variables is observed in Eqs. 6 and 7, the total possible number of nonzero taps is actually less than N, since:

$$\mu_i(1)\rho_i(1) = 0, \quad 0 < i < N. \qquad (8)$$

In most adaptive filter algorithms, including SHARF, the resulting filter structure contains a significant number of spurious taps within an autocorrelation width of the reference signal around main ghost-cancelling tap positions. The most significant enhancement in ISHARF is the nonlinear minimax windowing on updates activated in operating Mode 1, the primary operating mode of the ED processor. By employing sliding minimax windows on block updates adaptively, the number of these spurious taps can be minimized. This operation is performed by the "Tap & Update Processing" block shown in Fig. 4.

The nonlinear windowing operation sets all update elements within one sliding auto-correlation width window to zero. The process is applied separately to both feedback and feedforward tap update vectors. This technique has been effective in eliminating spurious tapping and ensuring convergence. It also allows the use of large adaptation constants that yield a fast response while avoiding convergence to nonoptimal local minima on the performance surface.

Although the convergence rate is expected to slow down due to the reduction of the number of coefficients updated per block iteration, the use of large update gain constants, that would otherwise destabilize the algorithm, compensates for this effect. In addition, the fast update of primary taps results in a rate of perceived picture-quality improvement that is faster than the corresponding improvement rate of the quantitative performance measures such as computed output signal-to-noise ratio (SNR) or mean-squared error (MSE).

The numbers of feedback (N) and feedforward ($M + 1$) taps are variable and are controlled by the system algorithm. The filter lengths are increased during convergence as much as necessary, up to a maximum number corresponding to a delay of half the active line time ($0.5H$). In this manner, the number of total operations is significantly reduced and the initial convergence speed is increased.

During the initial phase that follows a channel switching or power-on, the EDRP makes an estimate of the echo channel by evaluating the received reference line (VITL). This estimate is made after recursive time-averaging of the reference line over a certain number of transmissions to reduce the estimation errors due to channel noise. For high SNR, this estimate is very accurate, and optimal tap weights are obtained almost instantaneously in most cases. For very low SNR, no estimate is made, and the EDRP is switched to the "let-through" (no operation) mode, i.e., a_i, $b_i = 0$, for $0 < i \leq N, M$, respectively.

A constant-tap-leakage option is also provided in the algorithm. If an excessively large number of taps within an auto-correlation interval is detected, or convergence to nonoptimal minimum is suspected, the tap-leakage is turned on. If no change occurs within a prescribed amount of time, it is turned off again.

The algorithm performs one block iteration per reference line transmission. Due to time variations in the echo channel, reference transmissions per frame (or field) are recommended for satisfactory channel tracking. Considering the amount of time between two frames, currently available lower-speed digital signal processors can be used for the implementation of the functional diagram of Fig. 4 (i.e., computation of the filter taps), providing significant cost-saving in the final product.

For additional cost-saving, a trade-off can be considered. In this simplified technique, operating Mode 2, the algorithm is reduced to the real (i.e., noncomplex) mode of operation. Only the in-phase output of the synchronous demodulator is used, and one-channel A/D conversion and subsequent noncomplex signal processing are carried out. Although performance is usually acceptable, this mode is inferior to Mode 1 in all aspects and need not be provided in sets in which Mode 1 is implemented.

Mode 2 is the operating mode for baseband multipath EDRP applications where the complex (two-axis) processing in Modes 0 and 1 is not necessary.

System Control Algorithm

This master algorithm controls and coordinates various segments of the EDRP. It is represented by the "Controller" block in Fig. 4. Its primary function is to watch the adaptive algorithm and make necessary changes according to the programmed data in the system ROM. It makes the adaptive update assignments (μ_i, ρ_j) for the filter taps, selects the number of taps, estimates the multipath channel parameters, verifies that the adaptive algorithm and the determined programmable filter are stable, monitors convergence, switches the sliding minimax window and tap leakage on and off when necessary (mode selection), and performs other housekeeping operations for the EDRP.

Note that stable operation of the adaptive algorithm does not guarantee a stable ghost-canceller filter, since the adaptive algorithm bases its computations on finite-length, disjoint segments of input, i.e., VITLs transmitted every frame. However, a stable ghost-canceller filter can be obtained only from a stable adaptive algorithm, when such a filter exists for the particular multipath channel. For some multipath channels, a stable ghost-canceller filter cannot be found at all, and the adaptive algorithm may converge to an unstable filter. For this reason, the master algorithm must check the stability of the programmable filter as well as the stability of the adaptive algorithm. The default state for the EDRP system, after a channel switching or power-on, is the let-through mode, until the master algorithm verifies reliable operation and switches to a ghost-canceller mode of operation.

The additional slow-AGC and synchronous-carrier phase-optimization loops are also handled by the master algorithm.

Simulations

The described system was fully simulated on a computer with a digital image-processing facility. To simulate the echo effects on a color TV signal, a full broadcast channel simulator was implemented.[7] The obtained simulation results are satisfactory. Channel time variations are currently simulated in nonreal time due to hardware constraints.

Figure 5 shows the results of a simulated example to illustrate the system performance. The received signal contains four ghosts with the following weights and delays: 20% at 0.7μs, 50% at 1.7μsec, 25% at 2.5μsec, and 10% at 4.5μsec which correspond to ghost ratios of -14, -6, -12, and -20dBs, and relative ghost phases of

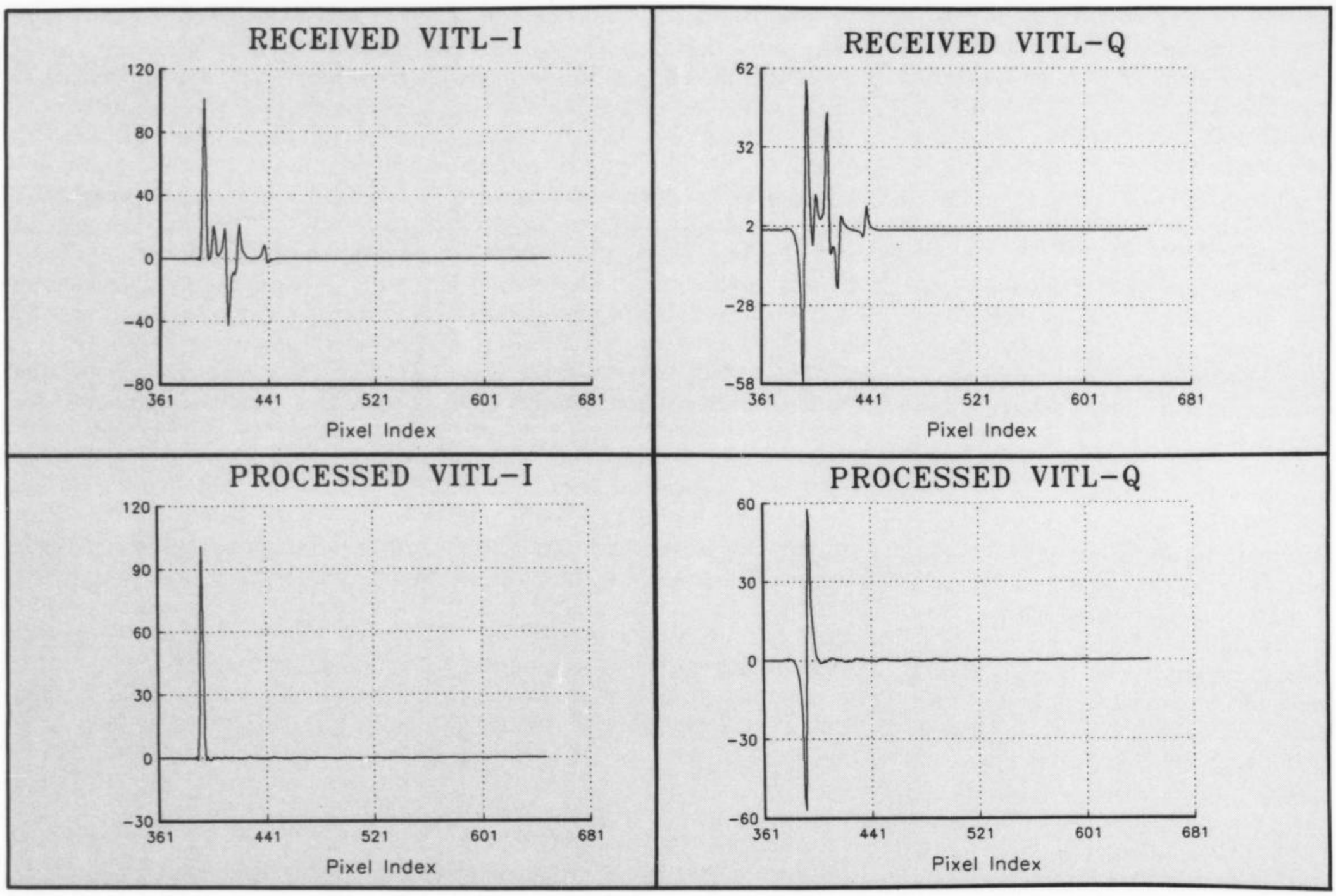

Figure 5. A simulation example: VITL profiles illustrate system performance for 4 ghosts; I and Q denote in-phase and quadrature components, respectively.

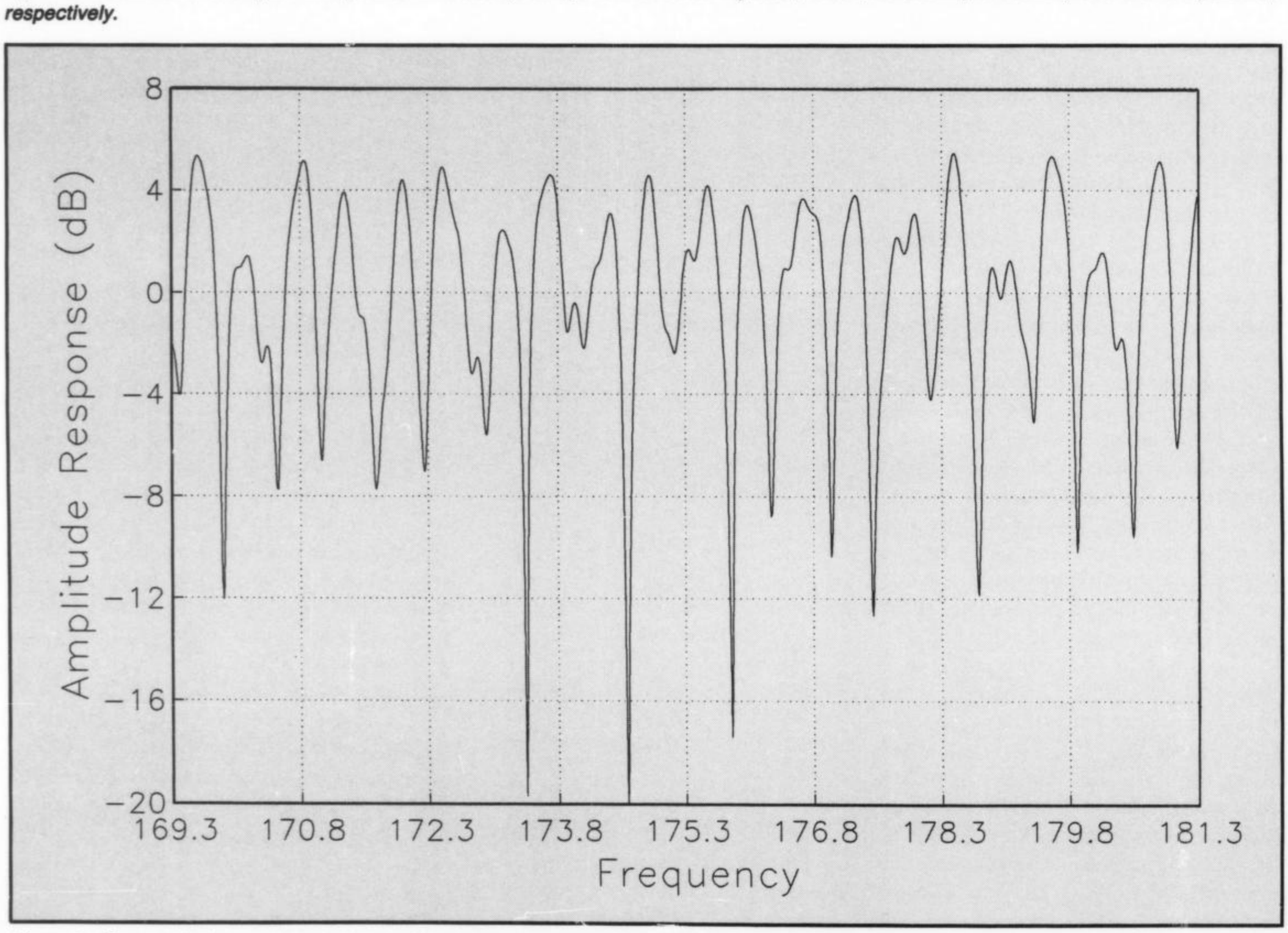

Figure 6. The amplitude response for the multipath channel used in the simulation example of Fig. 5.

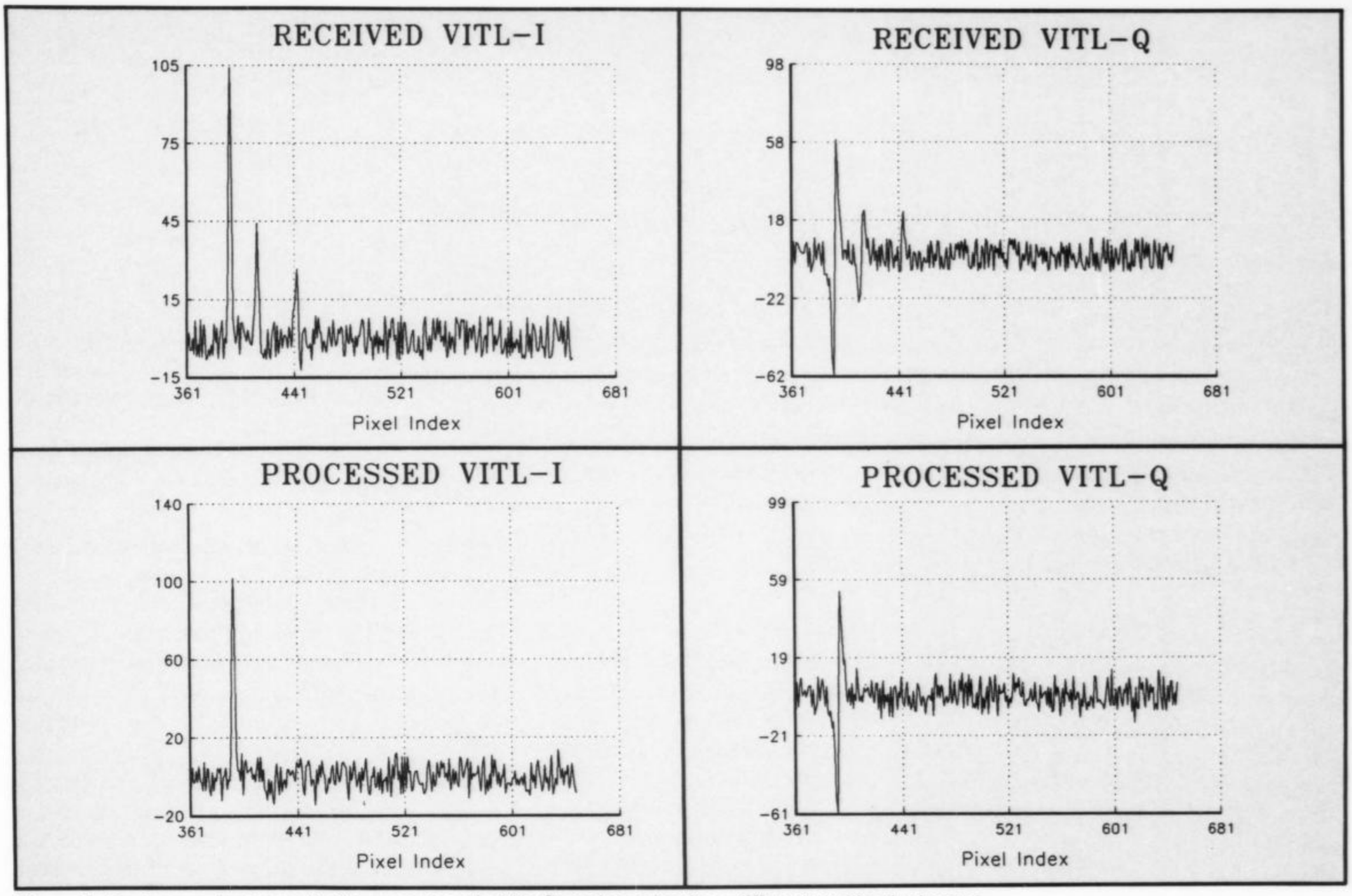

Figure 7. System performance in the presence of white Gaussian noise for a different multipath channel.

0, −121, −51, and −47 degrees (regarding the channel picture carrier), respectively. The amplitude response of the simulated multipath channel is given in a ±6-MHz wide frequency range around the channel picture carrier, in Fig. 6. The transmitted VITL contains a 40 IRE peak-amplitude 2*T* pulse at the center of the active line. The selected transmission is on North American Channel 7 with the picture carrier at 175.25 MHz in the VHF band. NTSC system characteristics are assumed in the broadcast simulator where the entire digital NTSC encoding and decoding processes including receiver comb filtering have been simulated. The source video signals are digitized at a sampling frequency of 10.07 MHz (640 f_H) at 8 bits/pixel per component. In Fig. 5, 100 IRE corresponds to the 8-bit format maximum value of 255 in the vertical scale. The algorithm was in an all-poles mode, i.e., all feedforward tap values, b_j, were set at zero, in order to illustrate stable performance potential. The figure shows both the in-phase and quadrature components of the received input and processed output signals for evaluation purposes. In the actual system, only the in-phase component of the processed signal will be used as the system output. An inspection of Fig. 5 reveals good ghost-suppression performance.

System performance in the presence of noise is illustrated in Fig. 7 for a different multipath channel. In this example, the received signal contains two ghosts with the following weights and delays: 40% at 2 μsec and 25% at 5 μsec, which correspond to ghost ratios of −8 and −12dBs, and relative ghost phases of 0 and −45°, respectively. The noise is additive white Gaussian with a standard deviation of 2 IRE. Other simulation parameters are the same as the previous example, i.e., channel 7 NTSC, 40 IRE 2*T* reference, all-poles mode. Inspection of the output VITL profile in Fig. 7 shows that the ghosts have been suppressed to below the noise level. Evaluation of the full-color picture (one static frame only) in search of residual ghost artifacts, that can be visible due to vertical correlation, also shows satisfactory ghost suppression.

Conclusion

A new echo-cancellation scheme has been described. The adaptive algorithm is fast and reliable. Due to the minimal number of filter coefficients for a given echo channel, the required programmable filter can be implemented as a very large-scale integration (VLSI) signal-processor chip in the near future. The system can easily be implemented in a digital TV set. Although development of the system has been for the NTSC standard, it is adaptable to PAL, SECAM, and most of the proposed HDTV systems, particularly those with compatible NTSC channels.

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The M.A.R.C. II System: A Modular Multiple Robotic Record/Play Videocassette System

By P. Livingston, M. Notani, M. Min, and M. Mifflin

Given that broadcast television operations are looking increasingly toward automation as an alternative mandated by economics, the previous generation of automatic cartridge or cassette playback systems have become outdated. By building on existing robotic technology, a reliable, deliverable system has been brought to fruition. By utilizing a modular library the system can be configured to meet individual requirements, and combining off-the-shelf operating system software with a readily available desktop computer has contributed to the rapid development and reliability of the overall system.

The television industry is undergoing a revolution fired by economics and changing technology, both within broadcasting and without. The cost of broadcast technical operations has mandated a new approach, and for many that means automation of manually-intensive areas. The goal is not only a reduction in manpower, but a concomitant reduction in required operator skill-level and improvement in on-air reliability.

One of the ideal areas for operational innovation is the videotape playback and library function for both spot and program material. The existing quadruplex cart machine technology is outdated. The machines are generally fully depreciated and the expense of continued operation is increasing in proportion to their decreasing reliability.

Matsushita Electric Corp., known in the U.S. as Panasonic, developed and delivered robotic-based videotape library systems as early as 1977, using first the ¾-in. format and subsequently ½-in. VHS. The library size ranged from 40 to 1600 cassettes and from 4 to 48 VTRs. By 1985, approximately 20 such systems had been installed. In 1983, Panasonic began delivery of nonrobotic M-format multitransport automatic playback systems for spot playback of multielement cassettes, utilizing the then revolutionary IBM PC for system management and operation. The MVP-100 used the computer and software in place of robotics and provided one deck for automatic dubbing, thus resolving element and time conflicts.

Clearly, the missing element was a fully broadcast-quality cassette-based format. In addition, it was also clear that the spot-only concept of these former systems was inadequate. Therefore, early in the development of the MII format, the physical size and weight of the cassette were given a high priority to allow the future automation of both spot and program length material. After a decade of extensive robotic expertise, the introduction of MII, a small-cassette format capable of outstanding video and audio performance, led to the development of the Multiple Automated Record/Play Cassette (M.A.R.C.) System.

The overall system design began with a few fundamental concepts or targets:

- Use standard, interchangeable VTR units
- Employ simple, reliable, straightforward robotics
- Exploit the ever-increasing power of small computers
- Provide modular library expansion
- Overbuild for long functional life

Before beginning a detailed presentation of the internal structure and how these criteria were met, a brief review of the product seems appropriate. The M.A.R.C. System's main unit consists of a linear 100-cassette library, five MII VTRs or players, and an *X-Y* axis robot with two *Z*-axis manipulators. The VTRs and the cassette library are in the same plane, accessible and visible through the transparent front doors. The VTR units, on which the control panels are

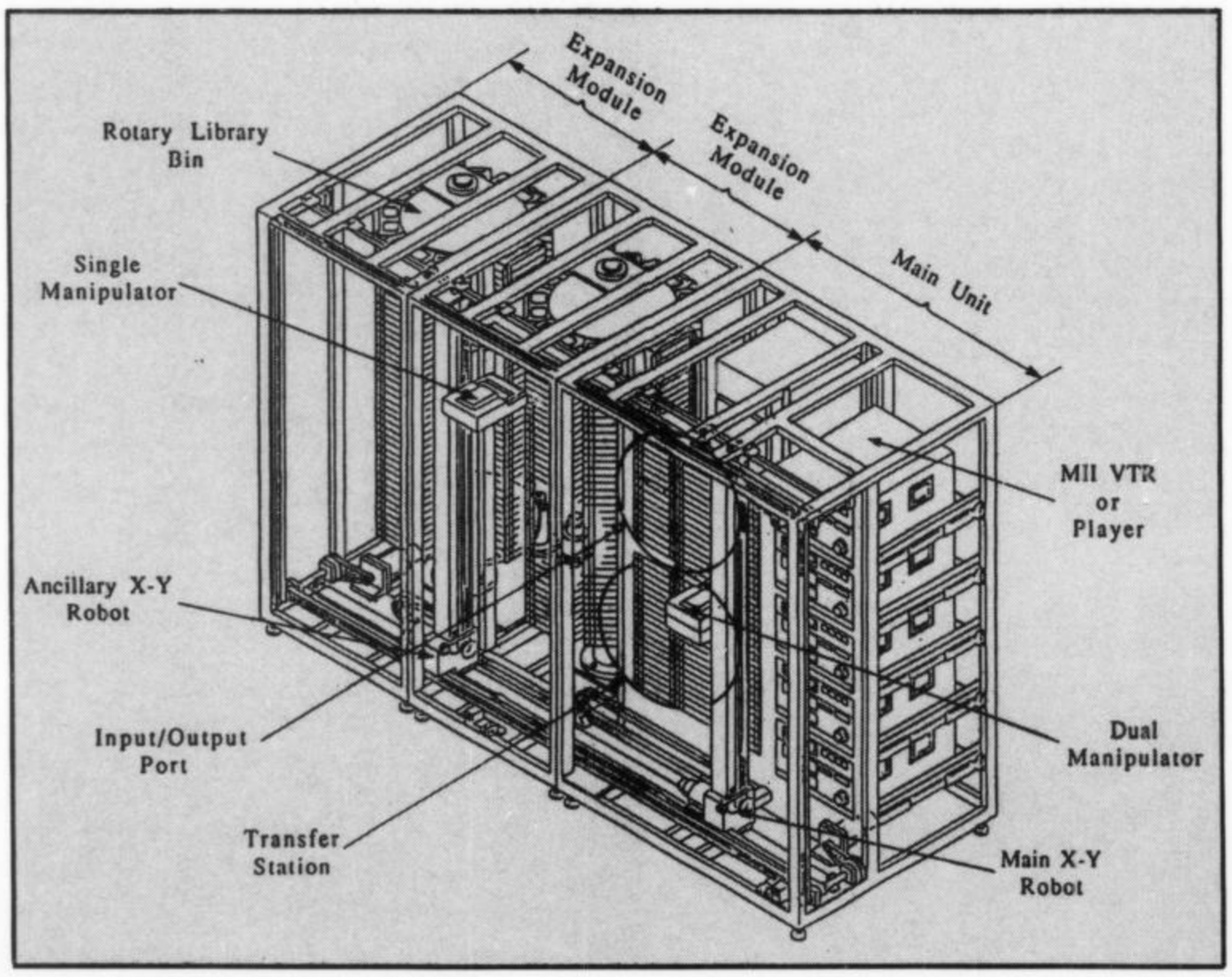

Figure 1. M.A.R.C. system structure.

Presented at the 130th SMPTE Technical Conference in New York City (paper 130-24) on October 18, 1988. P. Livingston (who read the paper), M. Notani, M. Mifflin, and M. Min are with Panasonic Broadcasting Systems Co./Matsushita Electric Corp. of America, Secaucus, NJ 07094. Copyright © 1990 by the Society of Motion Picture and Television Engineers, Inc.

available from the front, actually sit on slide-out rails that extend from the rear, allowing access while the system is in use and the robot moving. Since any mix of standard MII studio players or recorders may be used, units can be exchanged as needed. Because each MII VTR is completely self-contained and unmodified, the mechanics and signal system are matched and may be replaced in a single move. Even without more detail, one can see that the first criterion — use of standard VTRs —has been accomplished.

The robot rides on a rail in the base of the unit just inside the doors (Fig. 1). The robotic elements are moved by motors and cogged belts. Cassettes are identified by a semipermanent barcode. Each of the robot's manipulators has a self-scanning barcode reader. This basic system can be expanded from 100 cassettes to 450, 800, or almost 1200, through the use of add-on modules with 350-cassette octagonal rotary bins. When the system is expanded in this fashion, a second robot can be added to transport cassettes from the rotary bins to the main unit. This improves the cycle time for short back-to-back segments, and, since this ancillary robot travels on the same rail as the main robot, either robot can cover the entire system independently in case one fails.

The system is controlled internally by the Sequence Controller, which receives a playlist and instructions that have been produced in the associated Compaq 386-20 desktop computer. This computer is the human interface and control point. The playlist is a file of up to 1000 events that are to be executed. When the playlist is entered, cassettes not within the system library are identified, as are unknown elements, by checking the data base which resides in the desktop computer. The Sequence Controller instructs the Robot Controller to fetch and return tapes, starts the appropriate VTR, and switches the video and audio signals to the system output. It also drives an internal character generator which inserts information regarding the next eight events into the selected video output (Fig. 2).

With this overview in mind, let us consider the individual elements that make up the system, beginning with the robotics. As one of the world's largest manufacturers of robotics, the Matsushita Factory Automation Group contributed greatly to the design. There are hundreds, if not thousands, of Panasert robotic printed-circuit-board assembly systems in use. In concept, inserting components into a board is not much different from inserting a cassette into a VTR or library slot, so this existing and proven technology was used as the basis for development. In fact, the robotic concept meets the "straightforward" criterion in several aspects. First, it is electrically driven and readily understood by electronically oriented television people. Moreover, the movement in all three axes (X, Y, and Z) is similarly controlled, further improving understanding and reliability.

DC motors with an integral shaft encoder are used to provide the motion. Each axis has a "home" position, identified by a sensor (or sensors) in conjunction with the shaft encoder. From this zero point, all other locations are a numerical count away (Fig. 3). Since the robotic control microcomputers "know" the count or address of every location, they can compute the difference and give the motor drive circuits the proper direction and acceleration values. Since the X and Y axes are driven independently but simultaneously, it is apparent that the robot will travel in the appropriate curve.

Block Diagrams for M.A.R.C.

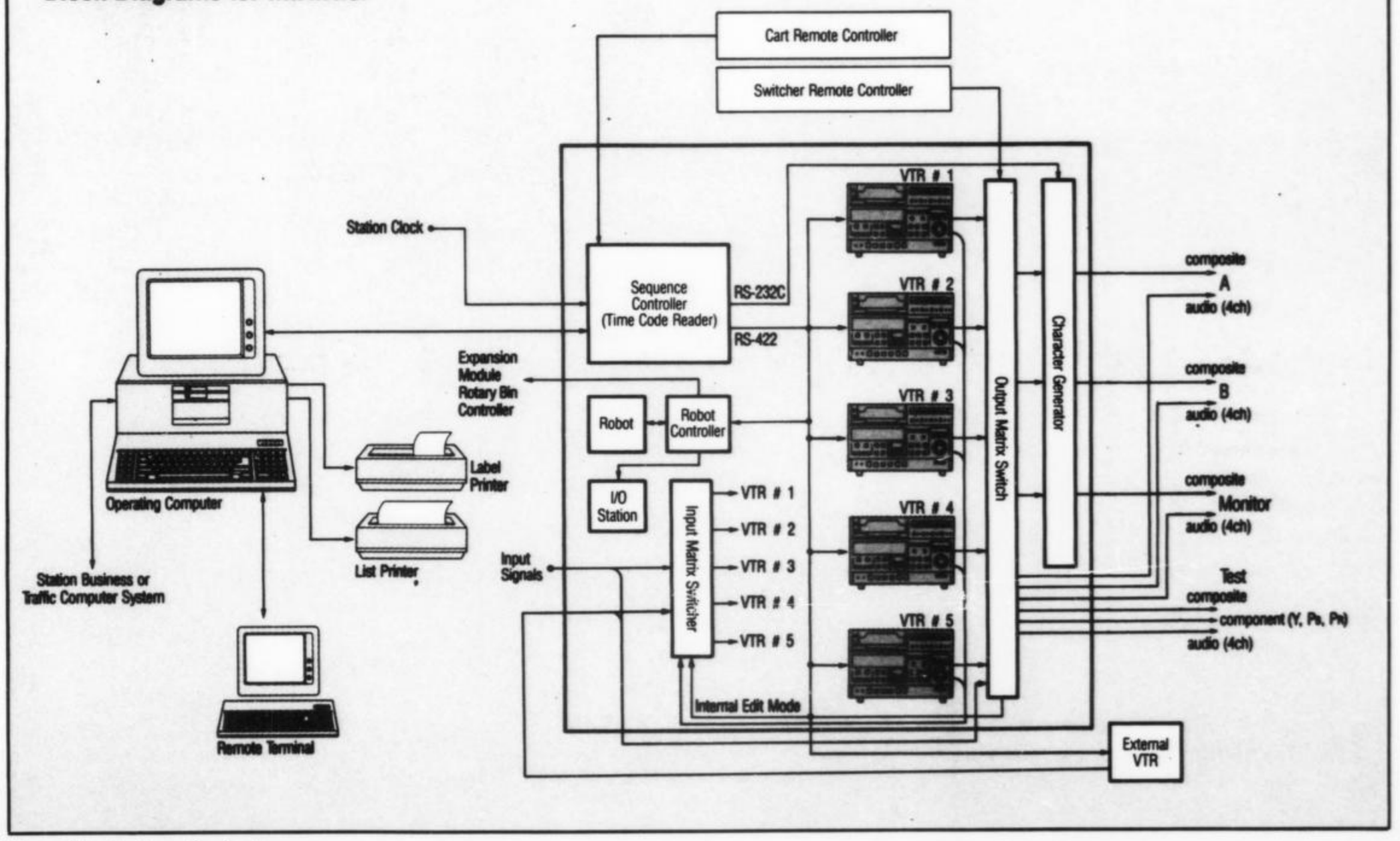

Figure 2. System block diagram.

When a motor moves a robotic element, the shaft encoder reports not only its position, but velocity as well. Therefore, the robot controller can monitor movement by comparison against a predicted set of values. In actual practice, the predicted values have an associated normal tolerance range. If the actual movement falls outside this, the operator is alerted that there may be a potential problem.

In addition to *X* and *Y* movement, the *Z*-axis cassette withdrawal and insertion is worthy of mention for two reasons (Figs. 4 and 5). One is the design of the manipulator jaws or chuck. The cassette is held by spring tension, not electromotive force, for fail-safe cassette gripping. The jaws themselves have a "heel" or rear protrusion, so that as the cassette is delivered to a VTR the jaws open but continue to push the cassette. This eliminates any "contention" between robot and VTR as the VTR loading mechanism begins its task.

The other is the use of an entire second manipulator assembly, which not only provides complete redundancy but also allows the staging or holding of the next cassette to be inserted, awaiting the ejection of the finished cassette. In terms of operational efficiency, this equates (approximately) to having one more VTR within the system.

When the system is expanded with the additional library modules, the rotary-bin control and drive is virtually the same as the other robotic elements. A motor drives the bin assembly from a known reference point, precisely locating each face parallel to the robotics by shaft encoder count. The numerical difference between present and desired location sets the speed of rotation, and this is checked by monitoring the encoder frequency.

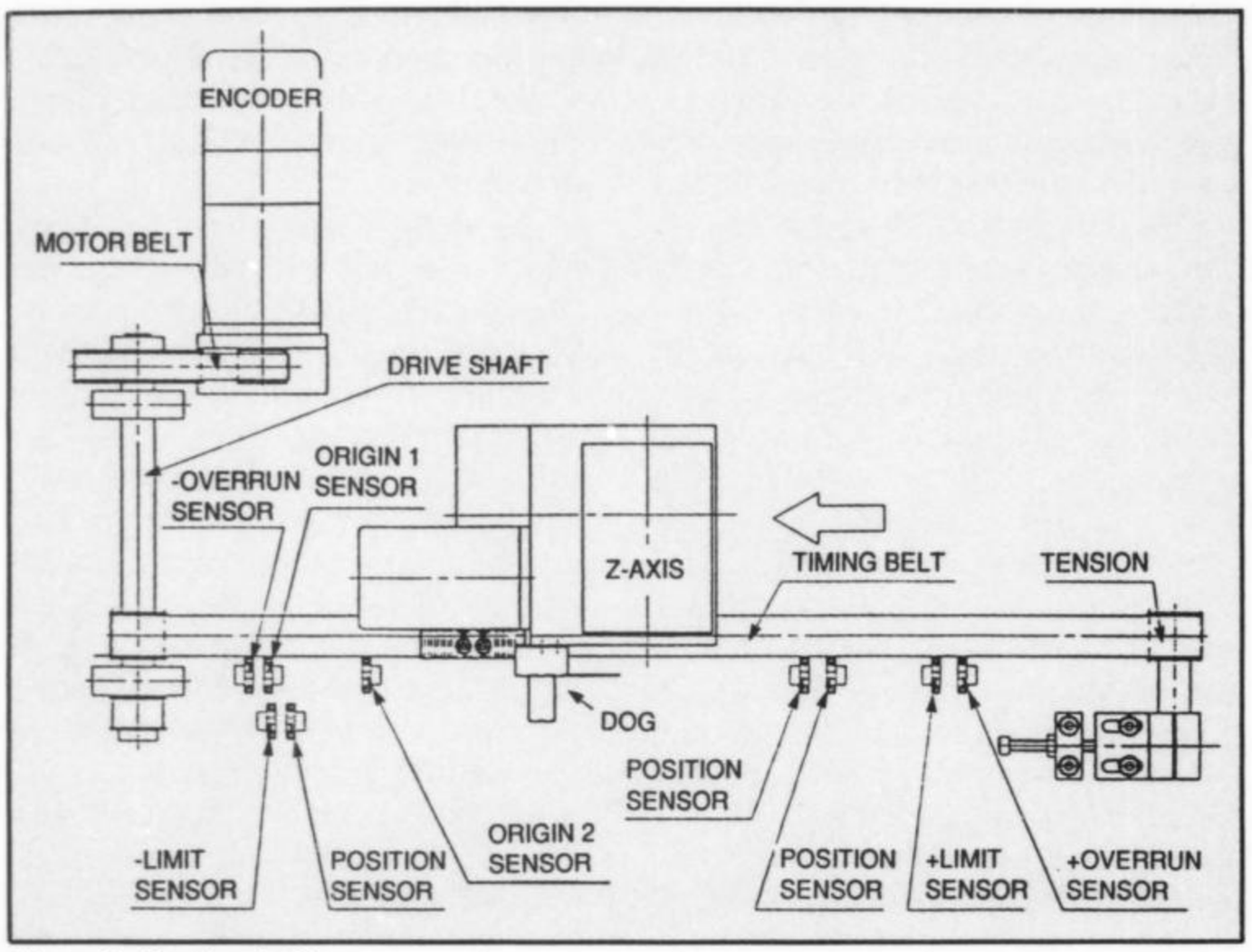

Figure 3. X-axis robotics.

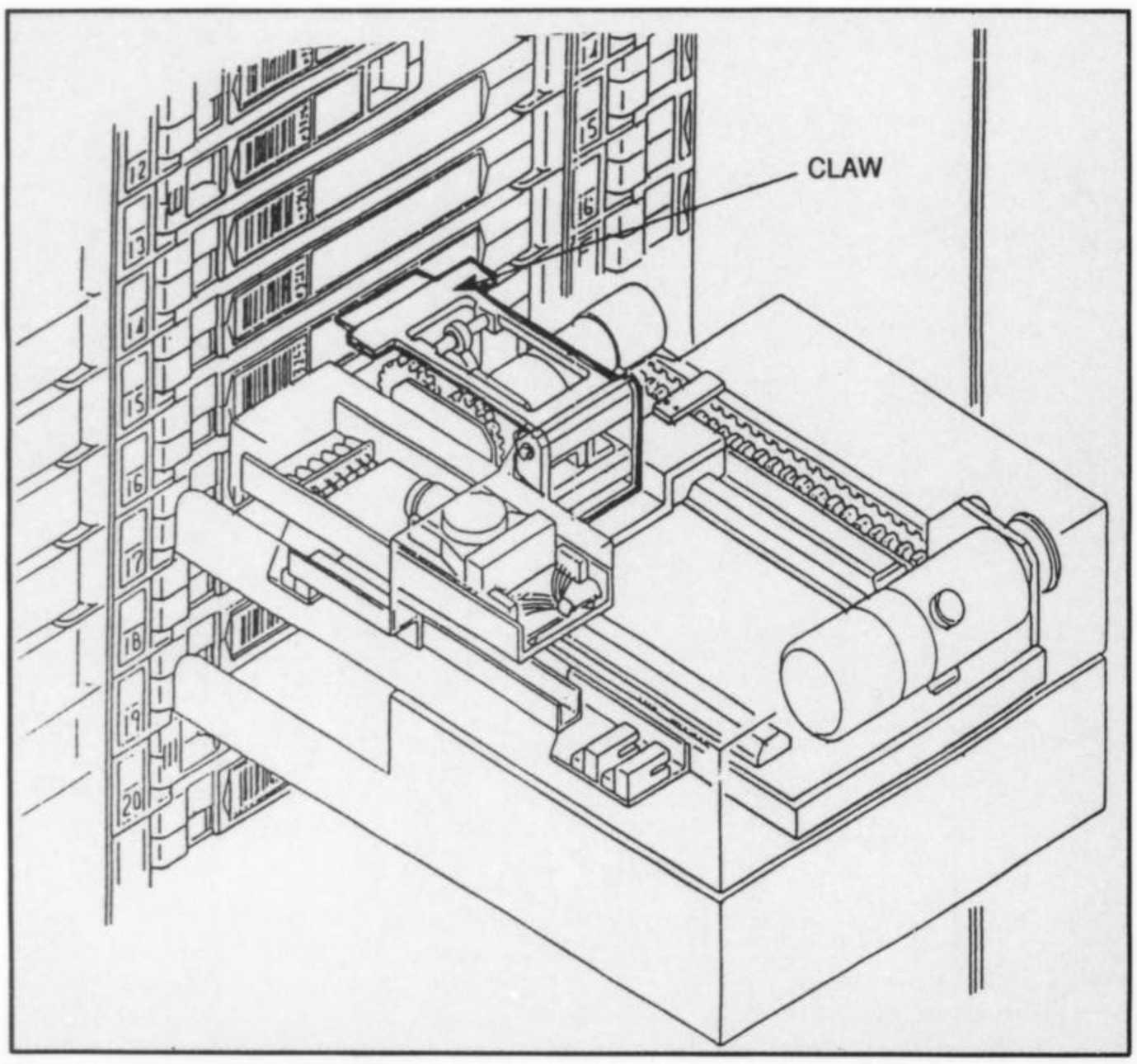

Figure 4. Manipulator assembly.

Operational Philosophy

Each physical cassette is identified by an eight-character barcode printed on a semipermanent label (Fig. 6). The labels are preprinted to assure uniformity, reliability, and durability. The characters may be chosen to represent the location in an external storage system or any other logical sequence. The barcode also identifies the cassette for tracking purposes, regardless of the material or element changes that may occur. Unlike some other systems, the identification of the contents of the cassette is retrieved from the data base mentioned previously. When the data base entries are made, either during the cassette dubbing process or independently, a secondary "human readable" label may be printed. This label is removable, so that it can be changed as the material on the cassette changes when cassettes are reused. Since each cassette may have single or multiple elements, each element is identified by a "material identification," usually used and assigned by a traffic department or advertiser. When an element is scheduled by the traffic system, the data base supplies the barcode of the proper cassette and the time code of the start-of-message for that element. A bin file, sent from the system to the computer data base,

is checked for the presence of the cassette within the system library. If present, the system is given the time code address as well as the bin location. At the appropriate time, the robot fetches the cassette, verifies the barcode, and inserts the cassette into an available VTR. The VTR cues the tape to the element start, less the preroll duration. The start of playback may begin on time, by external trigger, or upon the conclusion of the preceding element.

A cassette can contain a single event or multiple events. Since the tape may be up to 90 min long, the multiple events can be program segments. The system can be instructed to treat program material as one element, in which case it continues to play while the other VTRs play the spots as scheduled to fill the breaks (Roll-Through). It can treat each program segment as an independent element, in which case it advances and parks at the next segment start point while the other VTRs play the spots (Stop and Re-Cue).

The term playlist is actually a misnomer, because recordings may be scheduled as well. The ability to program a recording and subsequent playback has advantages for unattended satellite recording or program delay functions, both of which are within the system's ultimate capabilities. These functions further underscore the differences between this generation of automatic cassette systems and the previous one.

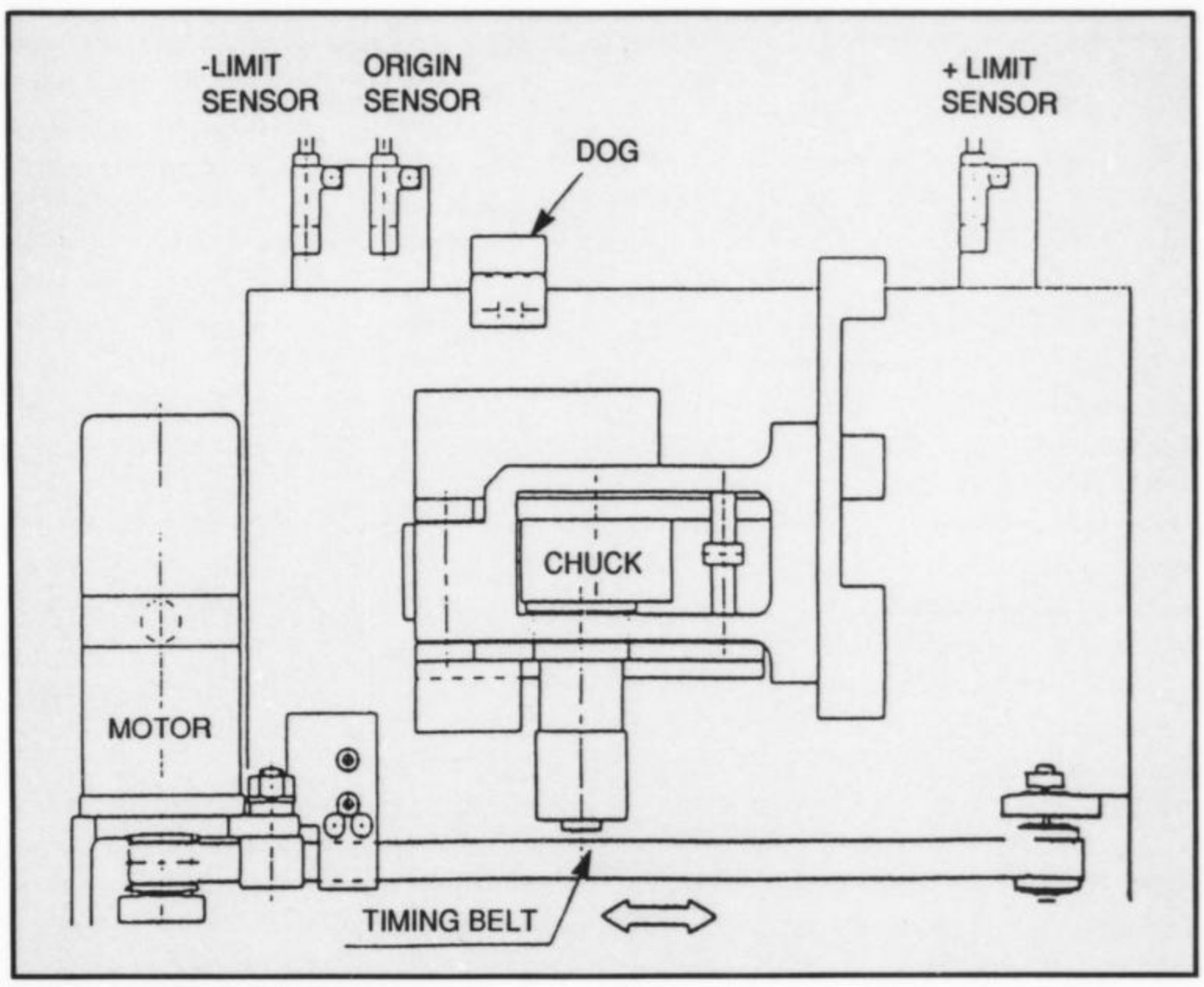

Figure 5. Manipulator sensors.

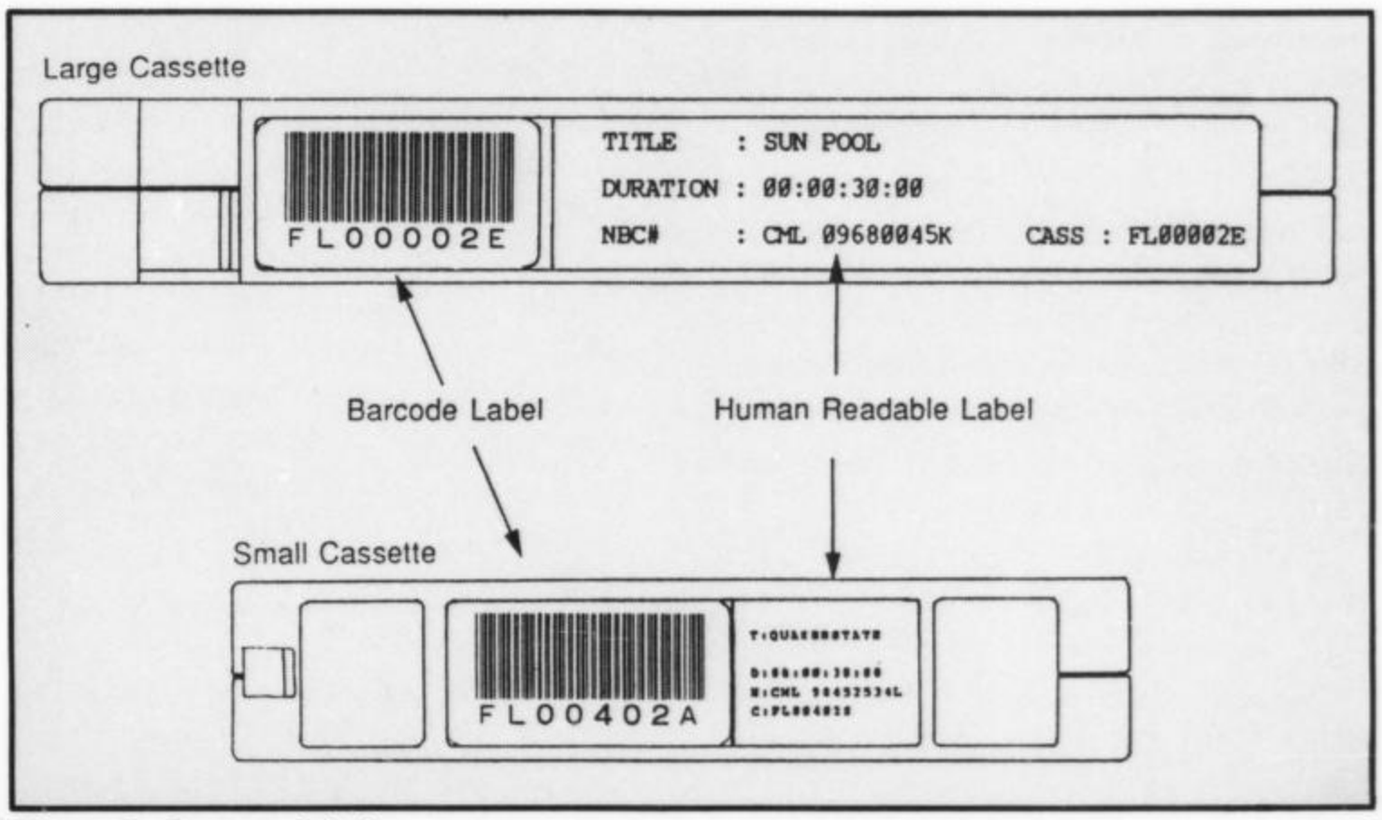

Figure 6. Cassette labels.

Computer Hardware

During the first year of development, the system utilized an Intel 80286-based desktop computer. However, it was quickly realized that the multitasking software was not executed fast enough to satisfy the operational requirements, especially the subjective "operator response time." Fortunately, the 80386 was on the horizon. Therefore, in order to provide the speed required to prevent operator frustration and maintain multitasking, the Compaq Deskpro 386-20 was selected. The combination of the 20-MHz clock, the Compaq architecture, which takes full advantage of the 32-bit Intel structure and the use of fast RAM under the Intel 82385 Cache Memory Controller, and a high-speed hard-disk drive all contribute to the performance of the system. Previously used in only larger systems, the cache memory holds the next logical information in a fast (35-nsec) memory so as not to impede the CPU or burden the entire system with expensive memory. For the M.A.R.C. System, the Compaq must have at least 5 Mbytes of memory.

Originally the system utilized an earlier form of Xenix that was appropriate for the hardware at that time. Subsequently, Santa Cruz Operation (SCO) Xenix V was selected for the M.A.R.C. II Operating System. It supports both multiusers and multitasking, while still allowing DOS disks to be used for transfer of files and lists to and from personal computers. Multitasking allows an operator to choose the major software portion he will use by selecting the desired window while the others run concurrently. For example, while a playlist is running, another playlist can be transferred, edited or verified, or new data added to the data base. The M.A.R.C. II software provides a simultaneous mix of real-time and nonreal-time tasks (Fig. 7). The four main functions or tasks which run concurrently are

- Operational control
- List editor and management
- Data base management
- System status, setup, and diagnostics

This use of off-the-shelf operating system software and computer system

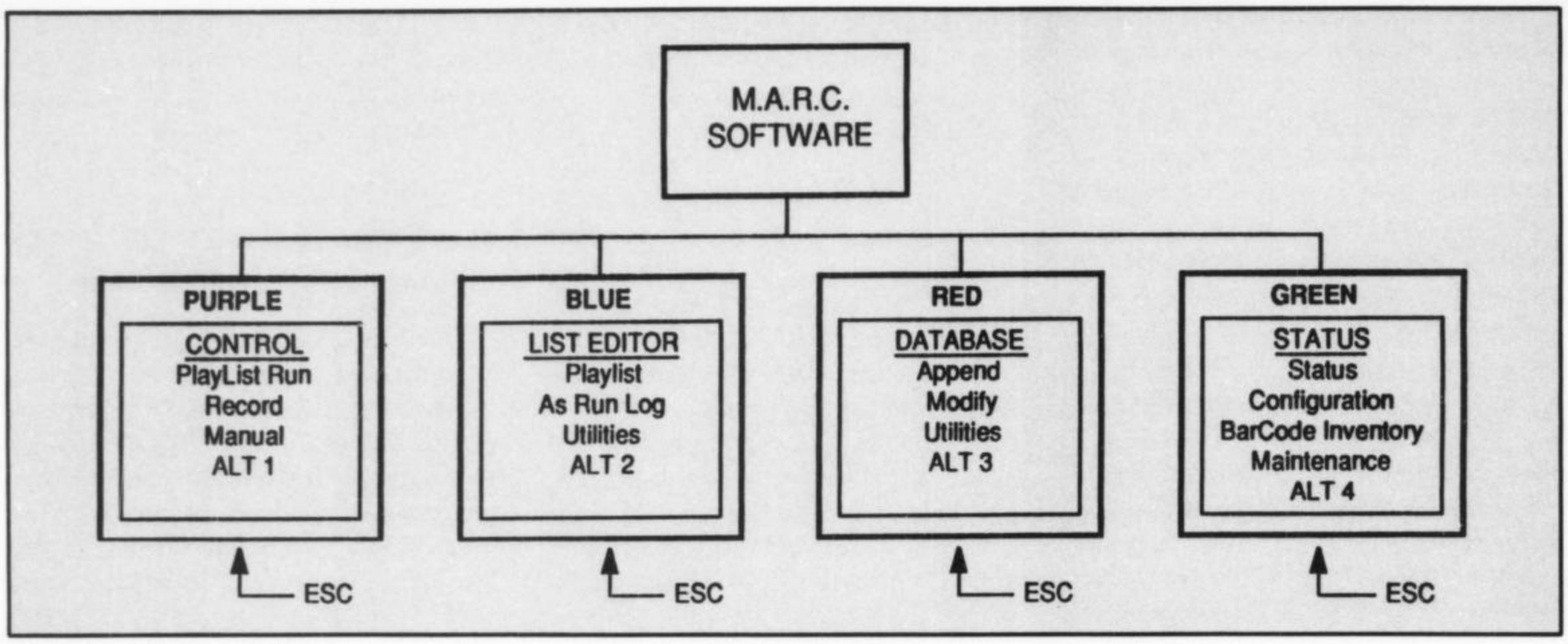

Figure 7. Software structure.

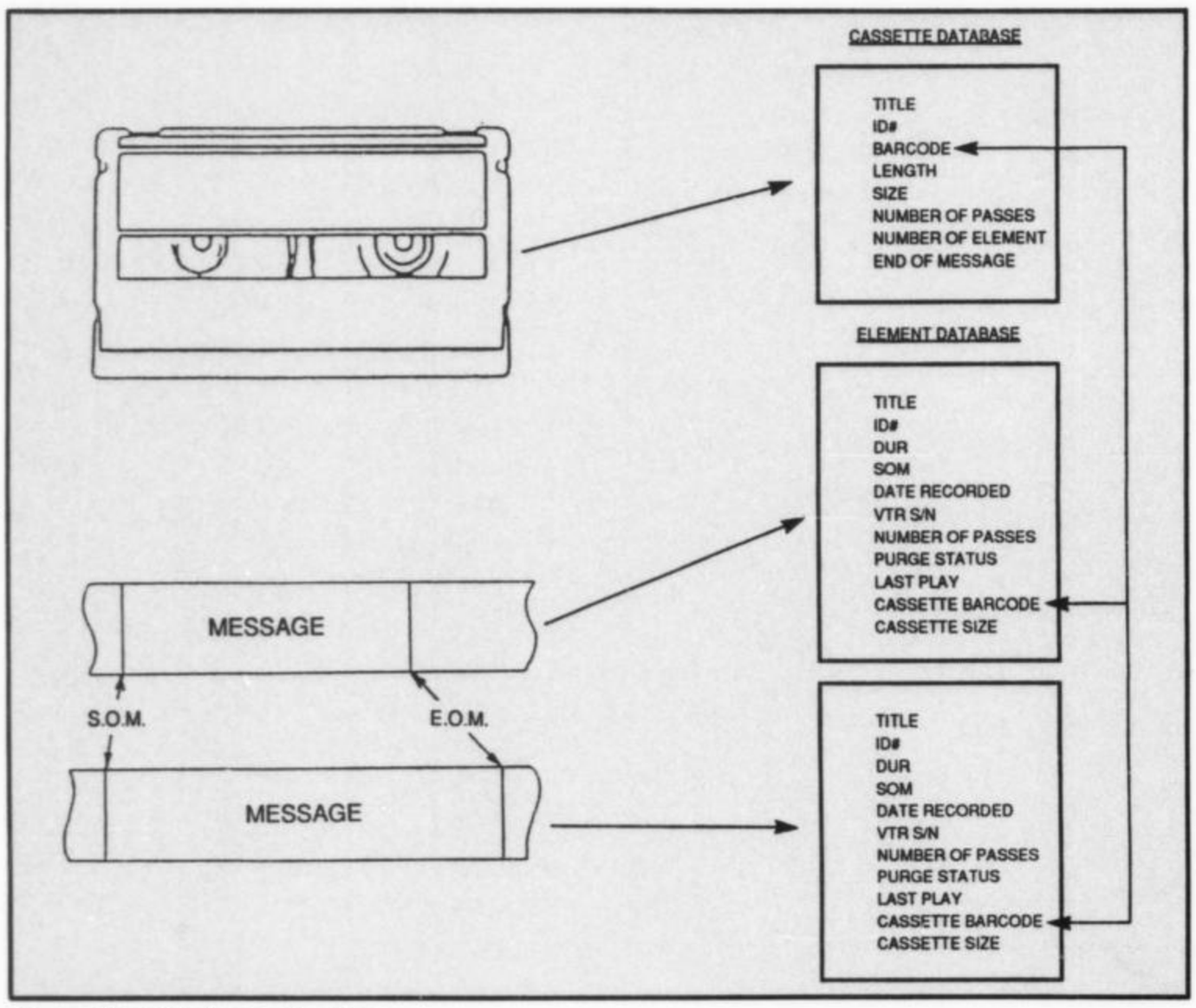

Figure 8. Data base structure.

hardware has enabled the system to keep pace with the burgeoning technology in this field and to take advantage of this continuous progress.

Data Base

One of the significant differences between the former generation of cart machines and the M.A.R.C. System is the utilization of a data base to store information beyond the simple location for the cassettes or the title of the material stored (Fig. 8). Given the power of the computer, information can be easily taken from the traffic system and discrepancies flagged. An operator can quickly search for a spot by any of a number of references for last minute changes, and cassette and element utilization can be tracked.

The M.A.R.C. II System utilizes a relational data base since cassettes may contain more than one element. The data base can contain more than 60,000 element records, and when backed-up on floppy disks, each disk contains approximately 10,500 records.

Each element or event file contains the I.D., title, barcode, start of message, duration, record date, purge status, passes, and record VTR. In addition, a library table holds the bin location within the system and barcode information.

The files can be searched or sorted by a specified key field, i.e. Barcode, Material I.D., or Title, which need not be complete. For example, search by title with only one or two letters entered will display all the titles beginning with those letters. This is called a Wild Card Search.

Conclusion

During the development and well into the introductory phase, one factor became apparent — the capabilities of the robotics and computer in conjunction with the modular library were handicapped by the fixed number of VTRs. For spot or program playback, four or five VTR units are sufficient. However, to exploit the full potential of simultaneous playback and recording for subsequent use, or program delay, more VTRs may be needed.

The Type III VTR expansion module was designed to answer this need. Built within a frame identical to the rotary-bin library module, using a VTR slide-rail system identical to the main unit, both of which were described earlier, this combination of previously engineered components will allow the addition of up to five more VTRs. These additional VTRs, coupled with the design flexibility and simplicity described above, allow the system to satisfy applications that are presently just a gleam in the eye of television broadcast management.

Acknowledgment

The authors recognize that the marks Compaq, SCO, Panasert, and Intel are the property of their respective owners.

The Care and Handling of Hazardous Nitrate Film at UCLA's Unique Projection Facilities

By Jess Daily

The UCLA Film Archive houses many nitrate films that are screened regularly in the university's Melnitz Theater. Since nitrate prints are extremely flammable, precautions must be taken each time they are projected. When nitrate burns, it produces its own oxygen and therefore cannot be extinguished. The Melnitz projection booth required extensive modifications in order to meet safety codes established for screening nitrate films. The modifications included the installation of a steel fire door with ports, which is lowered into position when nitrate film is present in the booth. A special interlock system was designed to prevent projection of nitrate films if the fire door is not in position. Safety rules include the inspection of every foot of nitrate film before it is projected and the presence of two licensed projectionists during nitrate screenings.

More than 50% of all American films have been destroyed or lost forever, with no prints or negatives in existence. The UCLA Film and Television Archive is dedicated to the preservation of motion pictures for future generations. It holds the second largest collection of moving-image media in the U. S.

The archive was created in 1971, when Twentieth Century-Fox and Paramount Studios donated all of their materials that were on nitrate stock to the university. Nitrate film decomposes in time, at different rates and with different results, and becomes more hazardous with age (Fig. 1). It can spontaneously combust and produces its own oxygen while burning; therefore it cannot be extinguished.

Melnitz Theater, built in 1968, is a popular Los Angeles showplace for films dating back to the beginning of the motion-picture industry. It runs an average of 75 hr of different film programs each week. The oldest screened print at the facility is an original nitrate tinted version of *Birth of a Nation* (1915).

When the theater was constructed, the projection booth was not built to code for handling nitrate film. But the only way to screen the older films, many of which are classics, is to run the nitrate print. (Transfer of nitrate materials to safety film is extremely costly and sometimes impossible without losing quality since original materials no longer exist.) There is a strong desire to run the nitrate prints before they deteriorate and are no longer projectable.

In 1977, a major conversion of the projection booth was started to bring it up to nitrate safety codes that were written in the 1930s and 1940s. Since the codes were written for new nitrate film, even more caution was needed with the old nitrate film.

Today, the booth contains two Norelco FP-20 35mm projectors; two Norelco FP-16 16mm projectors; a Peterson six-track, 70mm sound system; Xetron lamphouses, with continuously variable output rectifiers; and a Magna-Tech six-track dual dubber.

The FP-20 Norelco projector safety features include

1. Magazines for the film reels with fire-trap sprockets to prevent the spread of fire to a reel of film.
2. A buckle trip-switch above the aperture that will close the changeover dowser and stop the motor if the film breaks below the gate, causing the film to remain still. (If the film stops in the gate, it can be ignited by the heat from the lamphouse.)
3. A guncotton switch above the gate that will close the changeover dowser and stop the motor if there is a fire at the gate.
4. A door to prevent the projectionist from being directly exposed to a flash or flame.

Each of Melnitz Theater's projectionists must have a current license

IMPORTANT!
Any Nitrate film found in deteriorated condition shown below must be reported to the office manager at once!
FILM IN THIS CONDITION SHOULD BE PLACED UNDER WATER UNTIL PROPER DISPOSAL CAN BE MADE

Figure 1. Warning signs for nitrate film.

Presented at the 130th SMPTE Technical Conference in New York City (paper no. 130-7) on October 15, 1988. Jess Daily is the chief projectionist at the UCLA Department of Film and Television, Los Angeles, CA.
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issued by the state fire marshal's office. The operation of the booth is governed by posted safety regulations which include the length of time that nitrate can remain in the booth; routine inspection of prints; the presence of two projectionists for a nitrate show, with one always at the projector that is running the nitrate film; and the operation of a vertical fire door and booth exhaust system. There is also a lamphouse-exhaust warning system that indicates when the lamp exhaust fails.

In order to localize control features to each projector location, the theater has a customized control system that allows the projectionist to remain next to the machine that is in operation (Fig. 2). The functions of the system include projector motor and dowser controls, VU meter for house sound level, interlock controls, remote tape controls, houselight controls, and masking and curtain controls.

The most important feature, however, is an emergency stop button, to be activated in case of a fire. The emergency system closes all dowsers, stops all motors, cuts the power to all lamphouses, raises the houselights, and rings an alarm.

The remote control was designed and installed as a plug-in unit and is powered by dual redundant and regulated-power supplies. The system's "brain" is a control cabinet containing individual control modules, all designed and built in-house. (An example is the masking select module which allows preselect functions, all controlled from the booth.) Each module can be removed, tested, and repaired without interfering with the rest of the system.

Because Melnitz Theater screens movies that date back to the beginning of film projection, it must be able to run 13 aspect ratios (Table 1).

Table 1 — Aspect Ratios of Films Shown

16mm	35mm
1.33	1.33 (silent)
1.33 TV	1.15* (Movietone)
1.66	1.33 TV
1.85	1.37
2.66 (anamorphic)	1.66
	1.85
	2.40 (anamorphic)
	2.55 (anamorphic)

* Created in the early 1930s by adding an optical soundtrack to the edge of the 1.33 silent frame; never standardized.

Figure 2. The projection booth in operation.

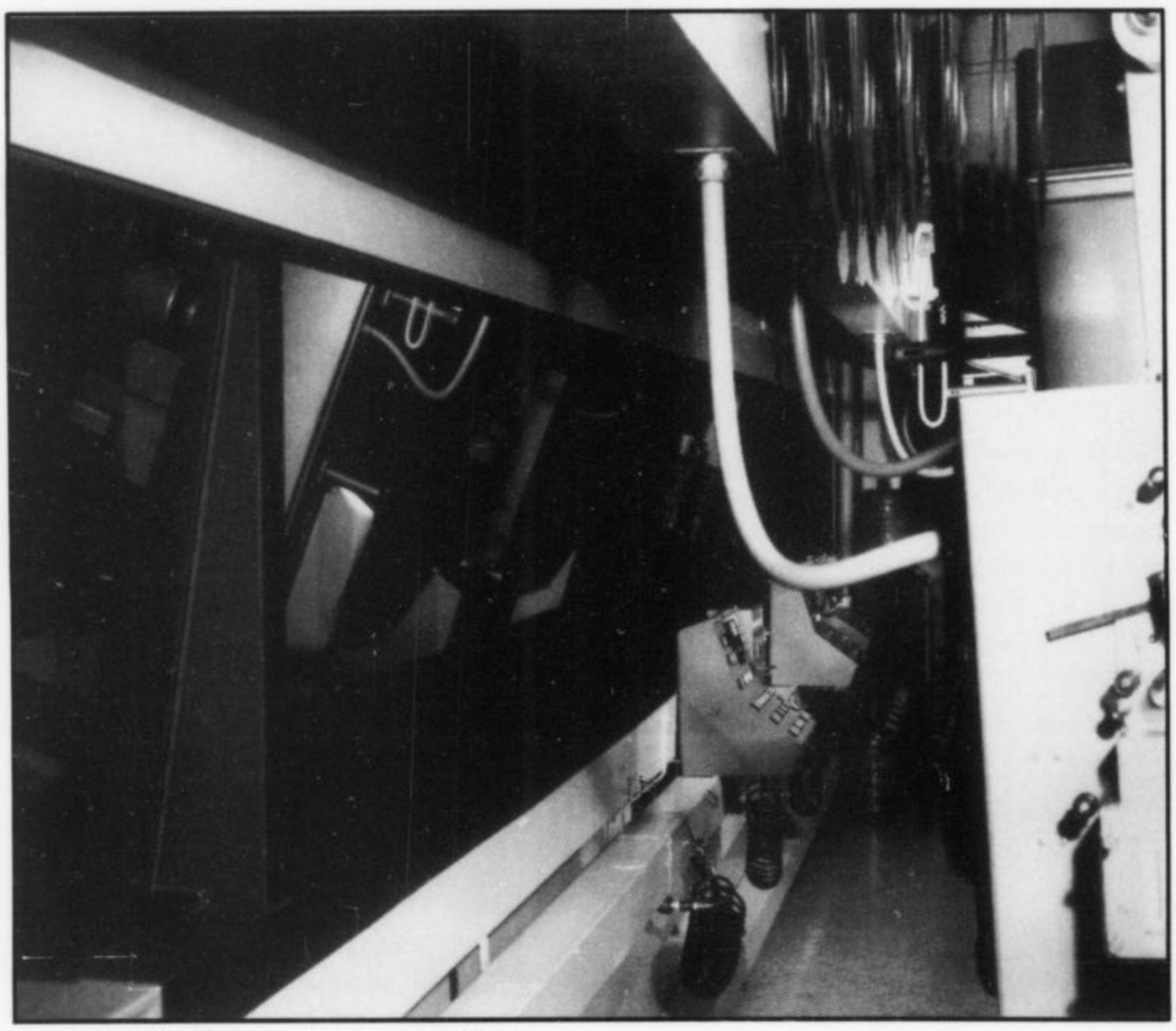


Figure 3. The fire door in its up position.

Each ratio requires its own aperture plate and lens. The screen brightness is maintained at 16 fL by the continously variable output lamphouse rectifiers.

The main feature that the UCLA Department of Film and Television wanted to retain in the new booth was a 31 ft wide projection and viewing port (Fig. 3). The port allows projection equipment to be added temporarily and also permits viewing of the screen from almost any position in the booth.

The port did not meet the nitrate code, which requires small ports with

fire shutters. But the fire marshal allowed the installation of a 2-in. vertical steel fire door, which would be up for normal operation and down when nitrate film is present in the booth (Fig. 4). The door, which has a 2-hr fire rating, is controlled by a key-operated electric motor. A tape switch along the bottom will stop the door if an object gets in its way.

Fire shutters in the door are held up by electromagnets connected to a smoke sensor in the ceiling (Figs. 5 and 6). Another smoke sensor in the ceiling is programmed to alert the fire department of a fire. An infrared safety beam across the ports triggers an alarm if anything crosses its path (a power failure could cause loss of fingers if the operator's hand is in a port). In addition, a variance was obtained to increase the size of the ports in the door. There is one projection port and one viewing port for each machine.

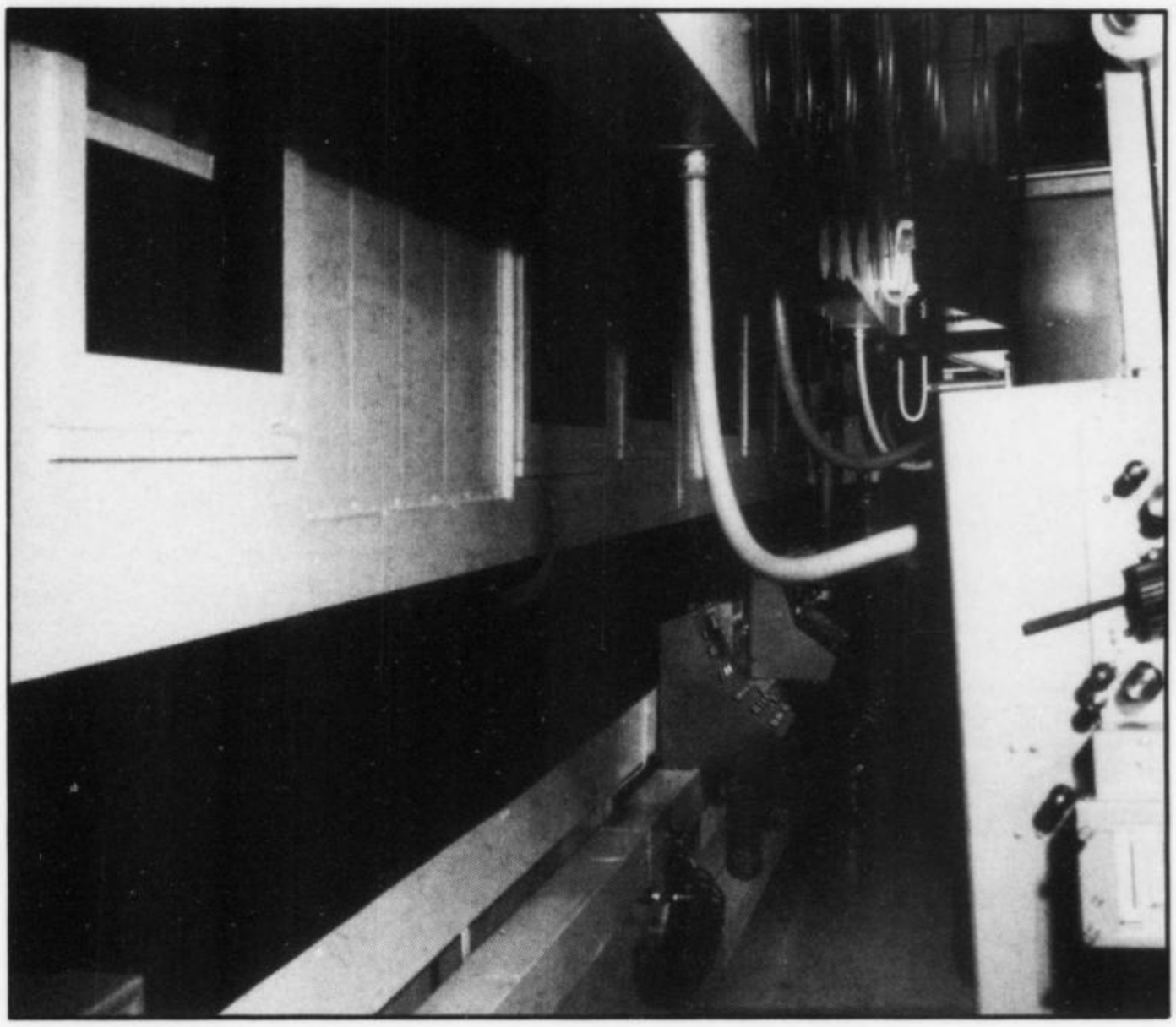


Figure 4. Fire door coming down.

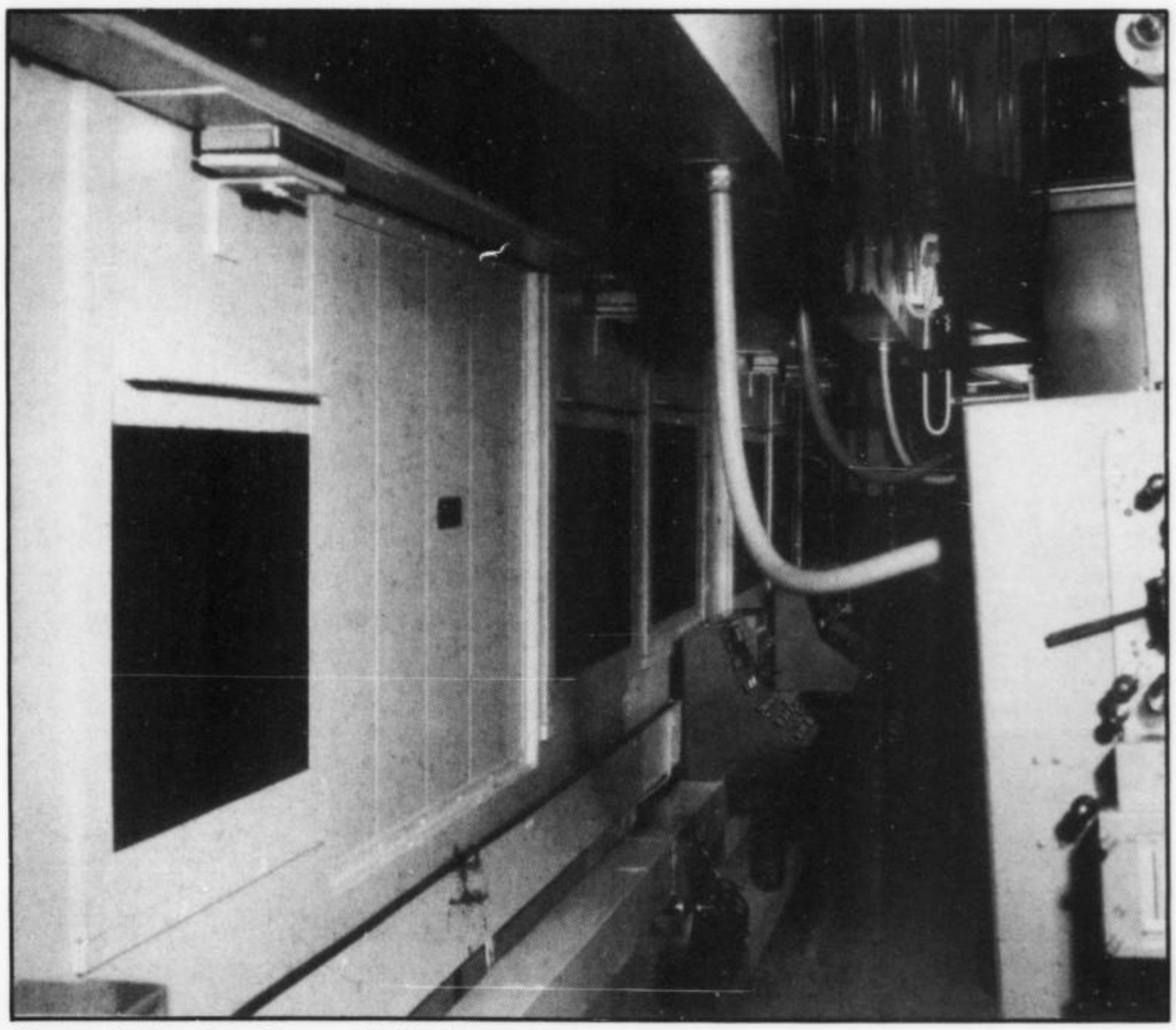


Figure 5. Fire door down, with its shutters up.

The fire marshal insisted that the 35mm projectors be interlocked so they would not operate unless the fire door was down. Since the theater runs a lot of 35mm safety prints, the film department proposed the installation of metal cue sensors on the projectors (to be interlocked with the fire door) and the placement of metal cue tape at 5 ft and 6 ft before the first frame of picture on the head leader of each reel of nitrate film. If the fire door is up and the cue sensor detects that the film is nitrate, then the projector dowser closes. The motor stops and locks out before the first frame of picture enters the gate.

The projector cannot be restarted until the fire door is lowered into "nitrate" position. A "lockout" pilot light tells the projectionist what has happened. The system deactivates itself after 5 sec, so that any extraneous cue tape on the film will not set it off. A "sense" pilot light on the control panel indicates if the system is working. All safety systems are tested weekly.

The projectors sit on electrically-controlled movable bases, to allow for the projection of aspect ratios without an optical track (1.33 silent and 2.55 CinemaScope) and for side-by-side comparison shows.

Certain modifications and additions to the Peterson sound system were also made including building and installing a monitor selector, to allow simultaneous monitoring of one to six channels; a meter panel, in order to read any channel at any number of places in the chain; and a combiner, to allow for the combination of up to four tracks to mono.

Also added were a six-channel dual distribution amplifier, a ¼-in. audio tape machine, an audio cassette machine, a turntable, a mic mixer for the PA system, and a full patch bay. The two six-track dubbers were modified to allow interlock switching for either dubber to any projector. The dubber has heads and preamps to run 16mm edge, center, and two-track and 35mm single, three-, four-, and six-track.

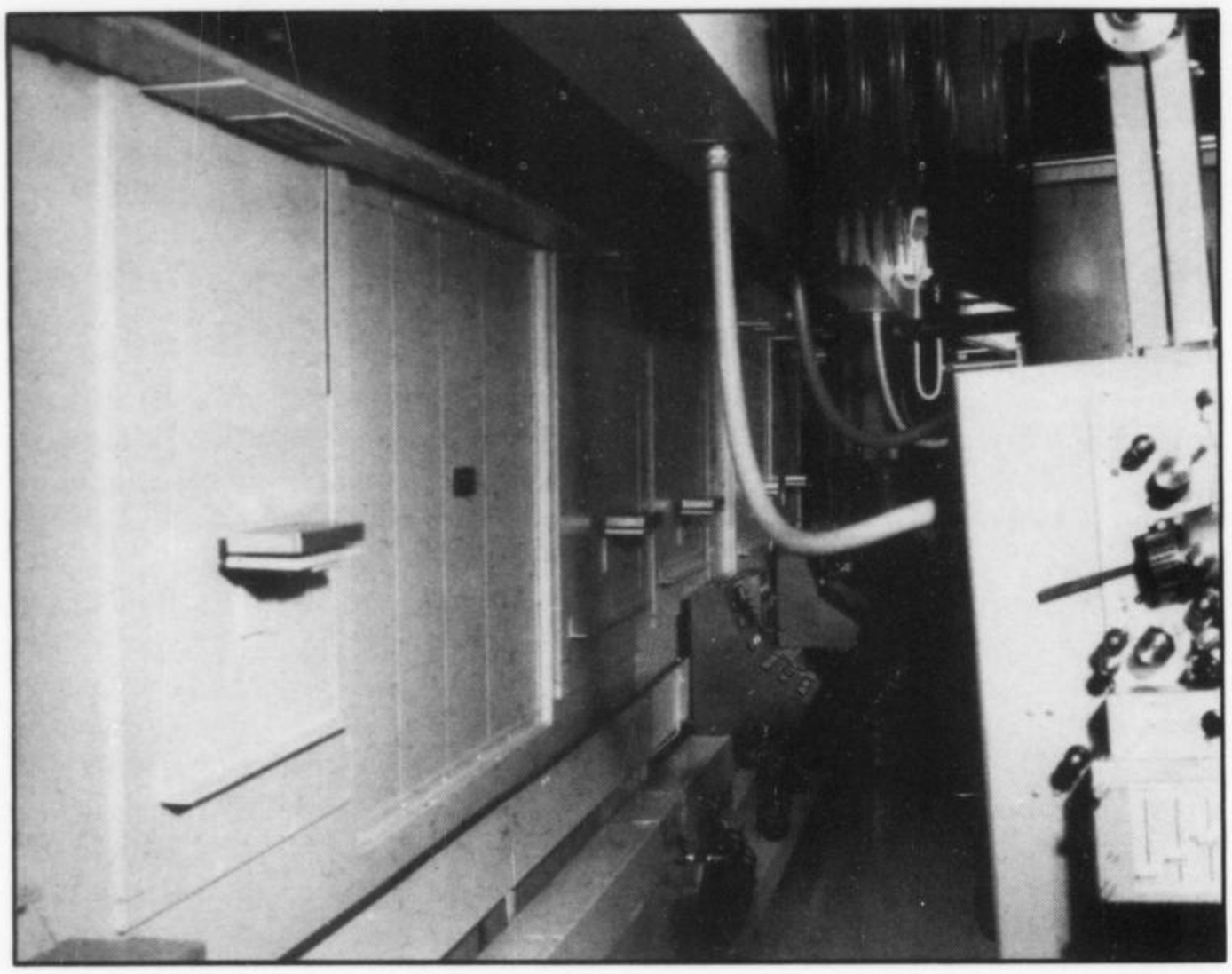


Figure 6. Fire door down, with its shutters down.

Sailor's Luck

MELNITZ THEATER
PROJECTION BOOTH 1406-A
PRINT CONDITION REPORT

TITLE: 1.

PRINT # M17990 SOURCE: ARCHIVE # OF REELS 8*

16MM A / B
(35MM) 70MM

SAFETY / (NITRATE) F.P.S. 24
COLOR / (B & W) RUNNING TIME

CUES:	MOTOR	DOWSER
RL 1		
RL 2		
RL 3		
RL 4	O	O
RL 5		
RL 6		
RL 7		
RL 8		
RL 9		
RL 10		
RL 11		
RL 12		
RL 13		
RL 14		
RL 15		
RL 16		
RL 17		
RL 18		

PICTURE FORMAT: 1.15 1.33TV (1.33) 1.33S
1.66 1.85 2.21 2.40 2.55 2.66

SOUND FORMAT: FADER: SILENT

(COMOPT)	16MM SEPMAG-1	35MM SEPMAG-1
COMMAG-1	16MM SEPMAG-2 (EBU)	35MM SEPMAG-3
COMMAG-4		35MM SEPMAG-4
COMMAG-6	16MM SEPMAG (CENTER)	35MM SEPMAG-6

PRINT CONDITION:
EXCELLENT (E); GOOD (G); FAIR (F); POOR (P)
Reel #: 1 G 2 F 3 G 4 G 5 G 6 G
7 G 8 F 9 ___ 10 ___ 11 ___ 12 ___ 13 ___
14 ___ 15 ___ 16 ___ 17 ___ 18 ___

COMMENTS: *1,000 FOOTERS ORIGINAL HEADS AND TAILS MISSING ON ALL REELS

CURTAIN

SPECIAL INSTRUCTIONS:
RL#1-NO TRACK FOR "ARCHIVE" LOGO
RL#8-2 MIN. EXIT MUSIC

DATES SCREENED:

DATE	PROJ.	DATE	PROJ.	DATE	PROJ.	DATE	PROJ.
8/7/88	JR/PM						

Figure 7. A print condition report.

The key to running successful, safe shows is print inspection. Following the safety regulations, every foot of film is examined before it is projected. Every foot of nitrate film is inspected twice, once at the archive's vaults (where it is stored loosely wound, emulsion-in, on cores in vault cans in vaults approved for nitrate) and again in the booth. However, projectionists are not permitted to inspect prints while running a show.

Inspection helps to guarantee a smooth show and to decrease the chance of fire or film or equipment damage. The projectionist checks for proper reel identification, sound and picture formats, changeover cues, and head countdown leader. He also repairs film damage and applies the metal cue tabs at the head of each reel of nitrate. Sometimes more time is spent preparing a show than running it.

During inspection, the operator fills out a print condition report (Fig. 7), which contains the film title, print number, number of reels, gauge, frame rate, running time, presence of false changeover cues, aspect ratio, sound format, condition of each reel, and any comments or special instructions. The report also indicates whether the film is color or black and white, nitrate or safety. The projectionist signs and dates the report and then files it for reference and for future screening of the same print.

The inspection bench contains an enclosed nitrate automatic rewind; an automatic rewind with tightwind attachments; light well; 16/35/35 scope cement splicer; 16mm and 35mm footage counters; a full complement of leader, cue markers, punches, and markers; and nitrate-approved film bins. A full range of house reels and an up-to-date collection of SMPTE sound and picture test films are also on hand.

By law, the booth is required to have fire sprinklers and extinguishers, two exits (one leading to the exterior), a booth exhaust system which imports 100% outside air, a lamphouse exhaust system, and an air conditioning system completely separate from the rest of the building. A communication system from the speaker vault, house, lobby, and box office to five different booth locations was also installed. Future plans include adding 70mm, silent speed capabilities, Dolby stereo, and THX sound systems.

Todd-AO: A History

By John Belton

Using 65mm camera film, specially designed wide-angle lenses, and six-track stereo magnetic sound, the Todd-AO system was first used to film Oklahoma, which was released in 1955. The success of this and a handful of subsequent Todd-AO films led to the introduction and establishment of a new wide-film standard of 70mm, which survives today as a major format for motion-picture presentation in the theater. This article reviews the development of the Todd-AO technology from the special wide-angle lenses designed by Dr. Brian O'Brien (former Professor of Optics at the University of Rochester), the 65mm Mitchell camera, the Philips Todd-AO dual (35/70mm) projector, and the Altec six-track magnetic sound reproducer to the system's "corrected printing technique," which eliminated distortion when wide-film images were projected onto a deeply curved screen from a high projection angle.

In 1989, the motion-picture industry witnessed the 100th anniversary of 35mm motion-picture film. Though 35mm film continues to be the dominant film format for commercial film production and exhibition, and was virtually the sole film gauge used by the industry for those purposes for over 60 years (from 1889 to 1955), it is no longer the only production and exhibition standard. Over the past 30 years, a second standard, that of 70mm, has entered the motion-picture marketplace. Today, there are more than 900 theaters equipped to show 70mm films and almost every blockbuster movie is screened in 70mm at these special, top-tier, first-run theaters.[1]

The term 70mm on a theater marquee or in a newspaper advertisement has become identified in the public's eye with the highest level of quality in motion-picture presentation. Like the trade name of Dolby Stereo, with which the term 70mm is almost invariably associated, a 70mm presentation promises, regardless of the quality of the film's dramatic content, spectacular entertainment values and, again like Dolby, is used to lure patrons into the theater. But, unlike Dolby Stereo, 70mm is not a trademark. It has established its special status in the film industry without the marketing muscle of a specific corporation within the service industry. It has become a generic term for wide-film, big-screen entertainment.

Though dozens of wide-film processes, ranging from del Riccio's Magnafilm (56mm, 1929) to Spoor and Berggren's Natural Vision (70mm, ca. 1930) and Fox's Grandeur Process (70mm, 1929), have been developed for adoption by the film industry, it was not until the 1950s, with the introduction of Cinerama, CinemaScope, VistaVision, and other widescreen systems that wide film emerged as a commercially viable solution to technical problems introduced by the widescreen revolution. Before Cinerama, which played on a 51 × 26-ft screen, and CinemaScope, which played on screens as large as 64 × 24 ft, the average screen size was 20 × 16 ft.[2] In blowing up images to fill this larger screen, CinemaScope, for example, enlarged its original 35mm film image 330,000 times, while the 35mm VistaVision frame, in projection, was enlarged 216,000 times (for a 55 × 27-ft image).[3] Both systems far exceeded the traditional 35mm Academy frame, which was enlarged 125,000 times (for a narrow 24 × 18-ft projected image). The sharpness and resolution of the projected image was suddenly put at risk, a danger which could only be eliminated by using larger negative areas in production and reducing them to 35mm for exhibition (as did the VistaVision and CinemaScope 55 processes) or by shooting and projecting films on wide-film stock. (Cinerama involved the use of three strips of 35mm film in both shooting and projection, as well as a six-perforation frame, which increased the height of the 35mm frame and the overall negative area.)

Todd-AO, introduced with the premiere of *Oklahoma* at the Rivoli Theatre on October 10, 1955, solved that problem, relying on a 65mm negative for filming, giving it 3½ times the negative area of 35mm film, and a 70mm print for projection (the extra 5mm being used to carry six magnetic soundtracks for stereo sound). Todd-AO achieved the sharpness and resolution of the average, pre-widescreen film, but did so on a bigger screen, enlarging, in projection, its five-perforation, 65mm frame 127,000 times (i.e., only 2,000 times more than the 1.33:1, 35mm projected image discussed above) to fill a 60 × 25-ft curved screen (Fig. 1). The commercial success of *Oklahoma* ensured that wide film and a new production and exhibition standard of 65/70mm would gain acceptance within the industry.

Though the Todd-AO trademark appeared on only a handful of films and the Todd-AO Corp. currently exists only as a sound-mixing lab, the original Todd-AO process, which prompted the development of Technirama (1957), MGM's Camera 65 (1958), Panavision 70 (1959), and Ultra-Panavision 70 (single-strip Cinerama, 1963), it is clearly the antecedent of the 70mm, multitrack, magnetic stereo-sound processes found in the film industry today. Though the growth of 70mm exhibition in recent years, which increased from 300 screens in 1982 to over 900 in 1988, is a complex phenomenon that is determined by a variety of factors, this article will suggest that the present growth of 70mm as an exhibition medium can be understood, in part, by an examination of the unique demands which it has satisfied in the past. In other words, a historical survey of the development of Todd-AO may be useful in devising solutions to certain problems that face the film industry today, and it may also infer the course theatrical exhibition will take in the future.

A contribution received from John Belton, Rutgers University, New Brunswick, NJ 08903. Copyright © 1990 by the Society of Motion Picture and Television Engineers, Inc.
Photos courtesy of the Academy of Motion Picture Arts and Sciences.

How Todd-AO Began

The development of Todd-AO, it might be said, began with the advent of Cinerama in 1952. As much as CinemaScope was seen by Twentieth Century-Fox as an answer to Cinerama and regarded by exhibitors as a "poor man's Cinerama," the Todd-AO process can be seen as Mike Todd's and the United Artists Theater Circuit's answer to Cinerama, attempting to duplicate the Cinerama effect but doing so at about half the cost. Todd himself was involved with Cinerama, owning a block of stock and producing the European sequences of the initial Cinerama film, *This Is Cinerama*. However, Todd and Cinerama parted company shortly after the release of that production, at which time he began work on his own widescreen process, one that would provide all of the entertainment values of Cinerama without any of its technical flaws.

The advantages of Cinerama included its overpowering illusion of audience participation, achieved in part by surrounding the spectator with image and sound (Fig. 2). Fred Waller's Cinerama sought to create a sense of depth and audience involvement by filling the spectator's field of vision, including peripheral vision. This was achieved by filming with three cameras, set in an arc at angles of 48° to one another, outfitted with three 27mm wide-angle lenses, which took in a combined angle of view of 145 × 55°, an angle of view that approached that of human vision, which is 165 × 60°. Sharpness and resolution were improved by expanding the negative area of each of the three synchronized 35mm filmstrips through the use of a six-perforation frame and by increasing the number of frames/sec for camera and projector from 24 to 26. By placing the spectator at the center of an image which was projected on a 51 ft wide, 25 ft high, deeply curved screen and surrounding the viewer with seven-track stereo magnetic sound, the Cinerama system virtually wrapped itself around the audience.

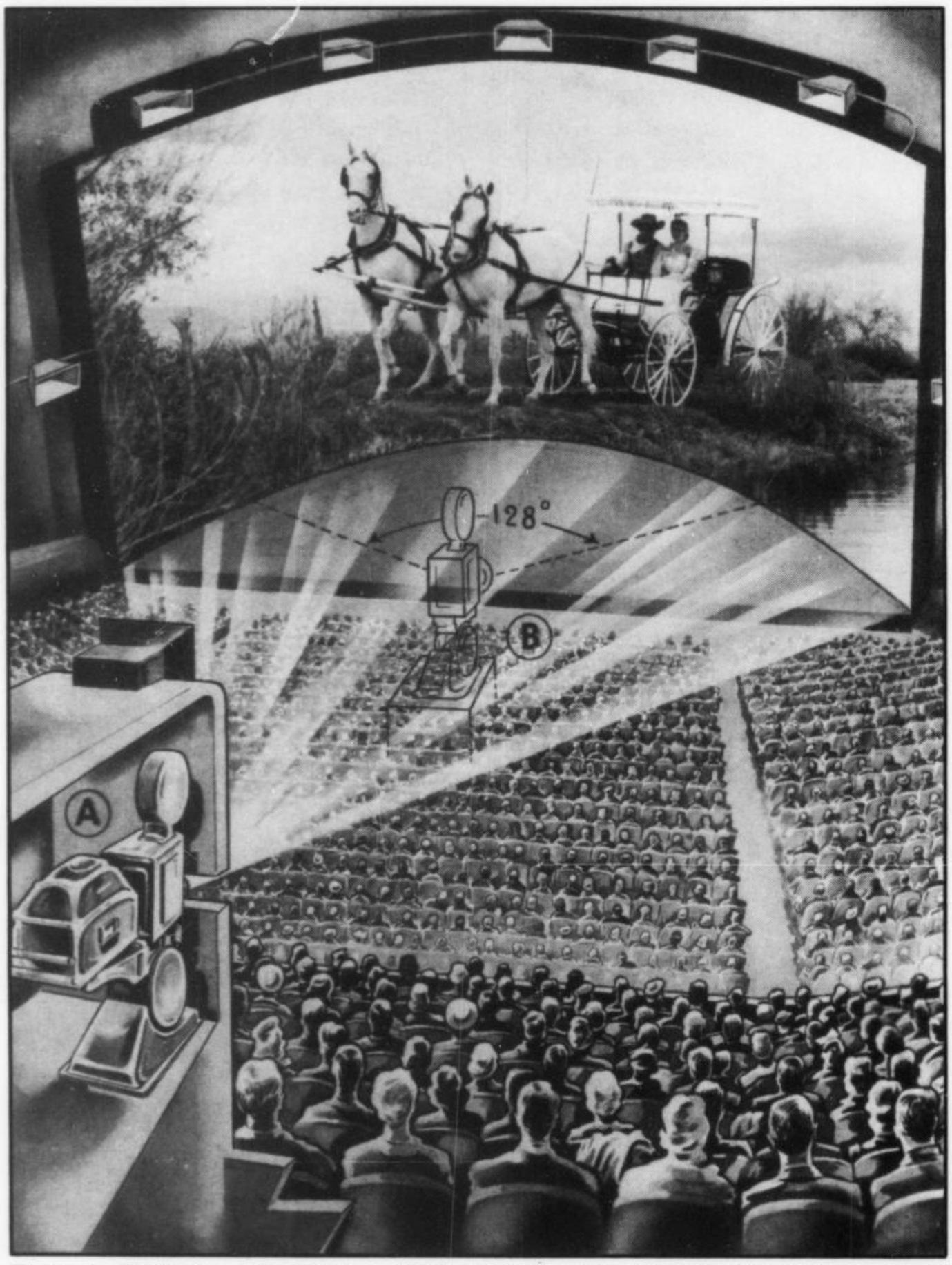


Figure 1. Oklahoma, projected by a single projector onto a deeply-curved screen. Seven speakers provided stereo sound.

Cinerama, however, was expensive to operate. Not only did it require more than three times as much raw stock and positive print footage as the standard 35mm feature film, but theater conversion and operating costs were so high that they prohibited its widespread adoption. The installation of Cinerama in a theater cost, according to various estimates in the trade press,[4] from $75,000 to $140,000 and, at the same time, forced a reduction in the overall number of seats. New York's Broadway Theatre lost 300 of its 1600 seats during the conversion process.[5] In one Los Angeles theater, the installation of Cinerama resulted in the loss of almost 1300 seats (from 2756 to 1468), which was more than most theaters at that time possessed. (The average number of seats in a theater at that time was 750.)

However, the chief limiting factor in the economics of Cinerama was not the one-time expense of theater conversion or the loss of seats but the constant increase in labor costs that it introduced. Indeed, Cinerama's operating expenses consumed about 50% of the gross.[6] Cinerama required the full staffing of three projection booths, a booth containing a picture-control engineer, and an additional sound control booth where an engineer oversaw the playback of the seven-track stereo magnetic sound. At the Broadway Theatre, 17 projectionists were required to put on a Cinerama show. It is no wonder that Roy Brewer of IATSE (the union that represented projectionists) praised Cinerama as the film industry's solution to the threat of television; at a time when theaters were closing at the rate of three per day,[7] it provided new jobs for his recently unemployed membership.[8]

Cinerama was not only expensive but was considered technically flawed.[9] Not only were the seams, where the three images joined, distractingly visible, but variation in projector illumination frequently resulted in accentuating this effect. In a

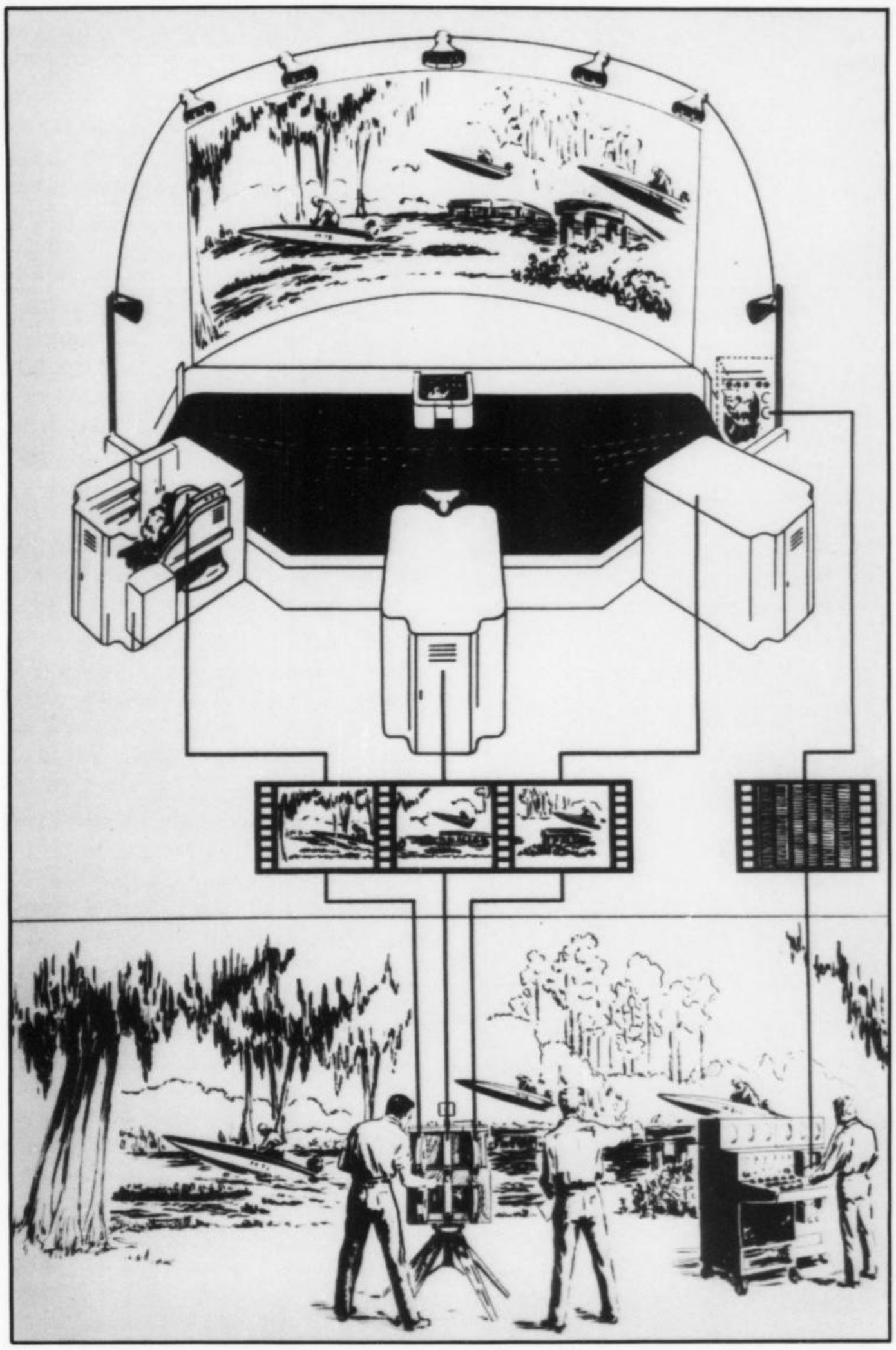


Figure 2. Cinerama employed three cameras in filming and three projectors in the theater. The deeply curved, widescreen image was accompanied by six-track stereo magnetic sound.

lengthy report on Cinerama, Fox engineer Lorin Grignon complained of inherent picture distortion, and noted that there were only a very limited area of seats where the visual effects are best. He advised that "the technical difficulties of identical projection from three separate machines and three separate prints all in exact register are extremely hard to surmount."[10] Indeed, projectionists encountered difficulty in keeping horizontal lines straight; operators in the right and left booths had to ride the frame knob in order to keep the right and left images in perfect lateral synchronization.[11]

At the same time, its unique technical properties became troublesome liabilities in the context of the industry's dominant product, commercial narrative cinema. Cinerama initially had difficulty telling stories. Traditional close-ups were impossible, given its lens technology. Cinerama's use of three 27mm wide-angle lenses resulted in noticeable distortion that was magnified in close-up cinematography. Unlike the single focal length required by Cinerama, traditional motion pictures employed a variety of different lenses. The optical restriction in the focal length of Cinerama lenses further reduced the medium's options, denying it what *New York Times* critic Bosley Crowther referred to as the basis of narrative cinema — flexibility of the images and the facility of varying the shots.[12] Without the close-up, which had become the linch-pin of film narrative, the medium was reduced to the primitive babbling of early cinema and virtually forced to choose the travelogue as its presentational format. That is, it was confined to nonnarrative material. Indeed, the first five Cinerama features were travelogues.[13] It was not until 1962, when MGM became involved with Cinerama, that narrative features, such as *The Wonderful World of the Brothers Grimm* and *How the West Was Won*, were produced.

Todd set out to remedy these defects while exploiting the participatory effects of wide-angle, deeply curved, widescreen motion pictures in multitrack stereo sound (Fig. 3). Just before the opening of Cinerama at the Broadway Theatre in New York on September 30, 1952, Todd complained privately to his son (and subsequent biographer) about the optical distortion in the side panels of the Cinerama screen and began work on his own Cinerama-like system.[14] Todd, who was essentially a Broadway showman rather than a Hollywood filmmaker, developed his Todd-AO system backwards, beginning with its final effect in the theater and moving from there back to the design of production equipment to achieve that effect. He attempted to recreate the experience of Cinerama for spectators in the theater by using a single film and projector rather than the three strips of film and projectors required by Cinerama. As Todd himself put it, he wanted a projection system "where everything comes out of one hole."[15]

Todd began negotiations shortly thereafter with Dr. Brian O'Brien, former professor of optics at the University of Rochester then serving as vice-president of research and development at the American Optical Co. (hence the initials AO in the name of the final process), to design a system of lenses that could approximate the angle of view of the three-lens Cinerama system. American Optical subsequently designed the lenses and optical printers for the system, as well as the lenticular screens used in initial

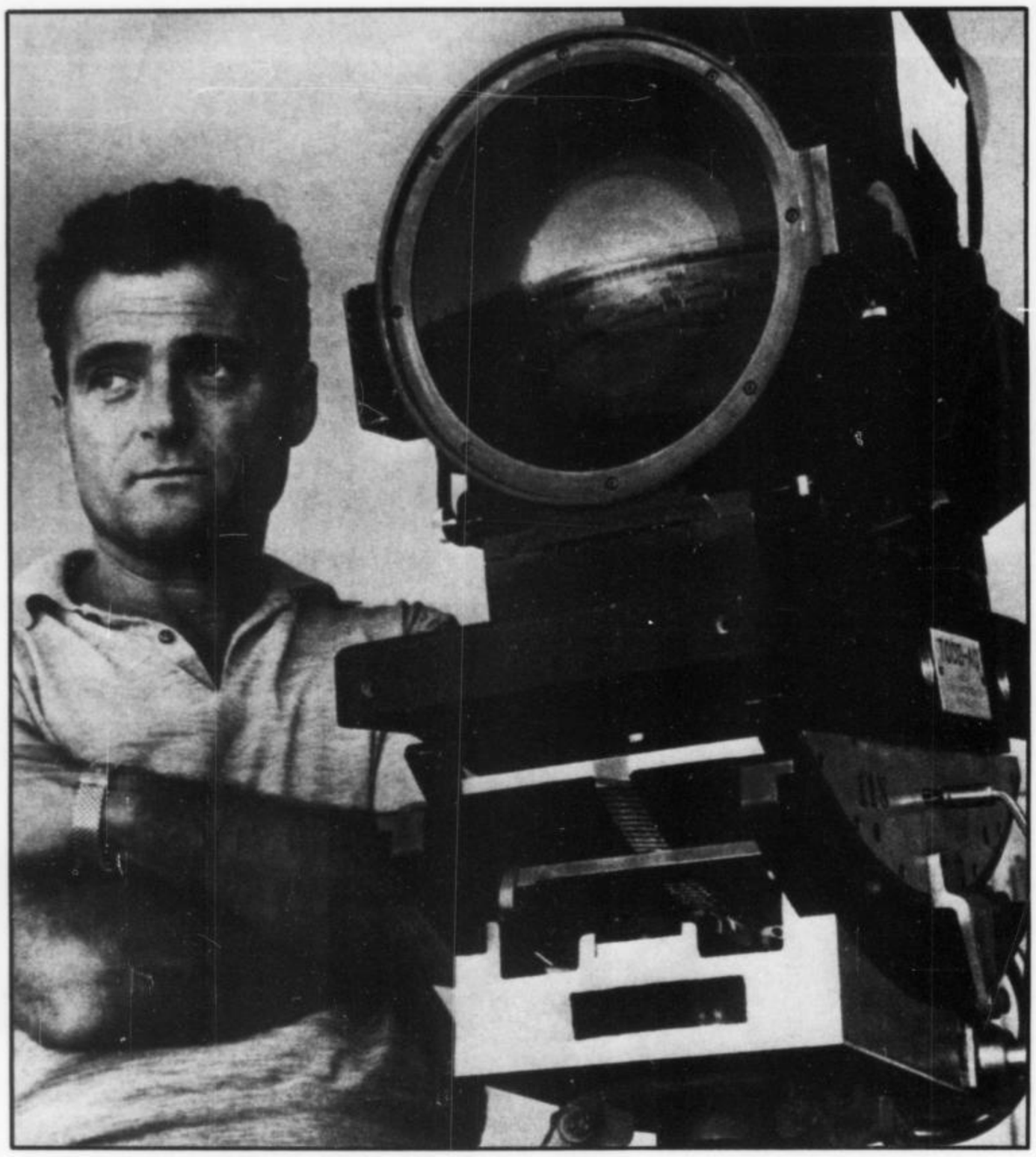


Figure 3. Producer Mike Todd with a Todd-AO camera.

installations. They also collaborated closely with Philips, The Netherlands, on the design of projection equipment. Dr. John Frayne of Westrex was enlisted to develop a six-track magnetic stereo sound recording system, while Altec contributed the magnetic sound heads, amplifiers, and "Voice of the Theatre" speakers. The Todd-AO camera, made by Mitchell, had a three-blade dissolving shutter with an opening of 170°, and ran at a speed of 140.25 ft/min, or 30 frames/sec rather than the 24 frames/sec of standard 35mm film (or the 26 frames/sec of Cinerama). This higher speed smoothed out action on the screen, improved sharpness and resolution, and made the projected picture flicker-free.

Similarities between Todd-AO and Cinerama

Angle of View

Todd-AO's 128°, "bug-eye" lens provides an angle of view that approximates that of Cinerama, which was 145° (Fig. 4). However, American Optical also designed three other lenses for the Todd-AO system. Their angles of view were 64°, 48°, and 37°, thus introducing a greater optical variety into the system that permitted the full range of expression traditionally found in 35mm production, which relied on a variety of lenses each possessing different focal lengths.[16]

This facilitated producers' use of the system for narrative films. *Oklahoma's* director, Fred Zinnemann, commented that "so far as I'm concerned, there is nothing that you cannot do with this medium. This includes the use of close-ups and complete mobility of the camera as regards pan shots, dolly shots, etc. The tremendous importance of this is that a story can be told by this process in motion-picture terms, and this to my mind is the difference between Todd-AO and Cinerama in which the camera is static."[17] Indeed, the first seven Todd-AO features — *Oklahoma*, *Around the World in 80 Days*, *South Pacific*, *Porgy and Bess*, *The Alamo*, *Can-Can*, and *Cleopatra* — fared quite well in competition with other narrative films of the period, winning a total of 11 Academy Awards.

Film Speed

Todd-AO's film speed of 30 frames/sec matched and surpassed Cinerama's 26 frames/sec, providing a steadier, more detailed image in projection. However, since this speed deviated from that used in standard 35mm projection (which was the exhibition industry's norm), Todd-AO was forced to shoot its first two productions in 35mm, 24-frame/sec, CinemaScope versions as well as in Todd-AO. This provided them with prints that could be run in houses not equipped with Todd-AO.[18]

Stereo Magnetic Sound

Todd-AO's six-track stereo magnetic sound system closely approximated Cinerama's seven-track stereo system. In fact, though designed as a single system format, Todd-AO, for initial theatrical presentations of *Oklahoma*, relied on a Cinerama-like double system, placing the six magnetic tracks on a separate strip of film that was projected in synchronization with the image.[19] It should be noted that Todd-AO's sound recording system, like Cinerama's, operated at the speed of 24 frames/sec, requiring special interlocks for post-production synchronization with the 30-frame/sec image track.

Increased Negative Area

Todd-AO's use of 65mm film and a five-perforation frame resulted in an image quality that approached the three-strip, six-perforation frame of Cinerama. Robert Surtees, director of photography on *Oklahoma*, said that Todd-AO's use of a 65mm negative made it, from the standpoint of optics alone, a superior picture process to all other 35mm widescreen processes.[20]

Deeply Curved Screen

Cinerama introduced the curved screen to motion-picture exhibition. Though curved screens automatically amplified the sense of audience participation by surrounding spectators with the image, they also presented several problems. Light reflecting from one edge of the screen struck the opposite edge, washing out the image. Cinerama's louvered screen, consisting of 1100 vertical strips, prevented the reflection of light back onto the other side of the screen. Todd-AO's

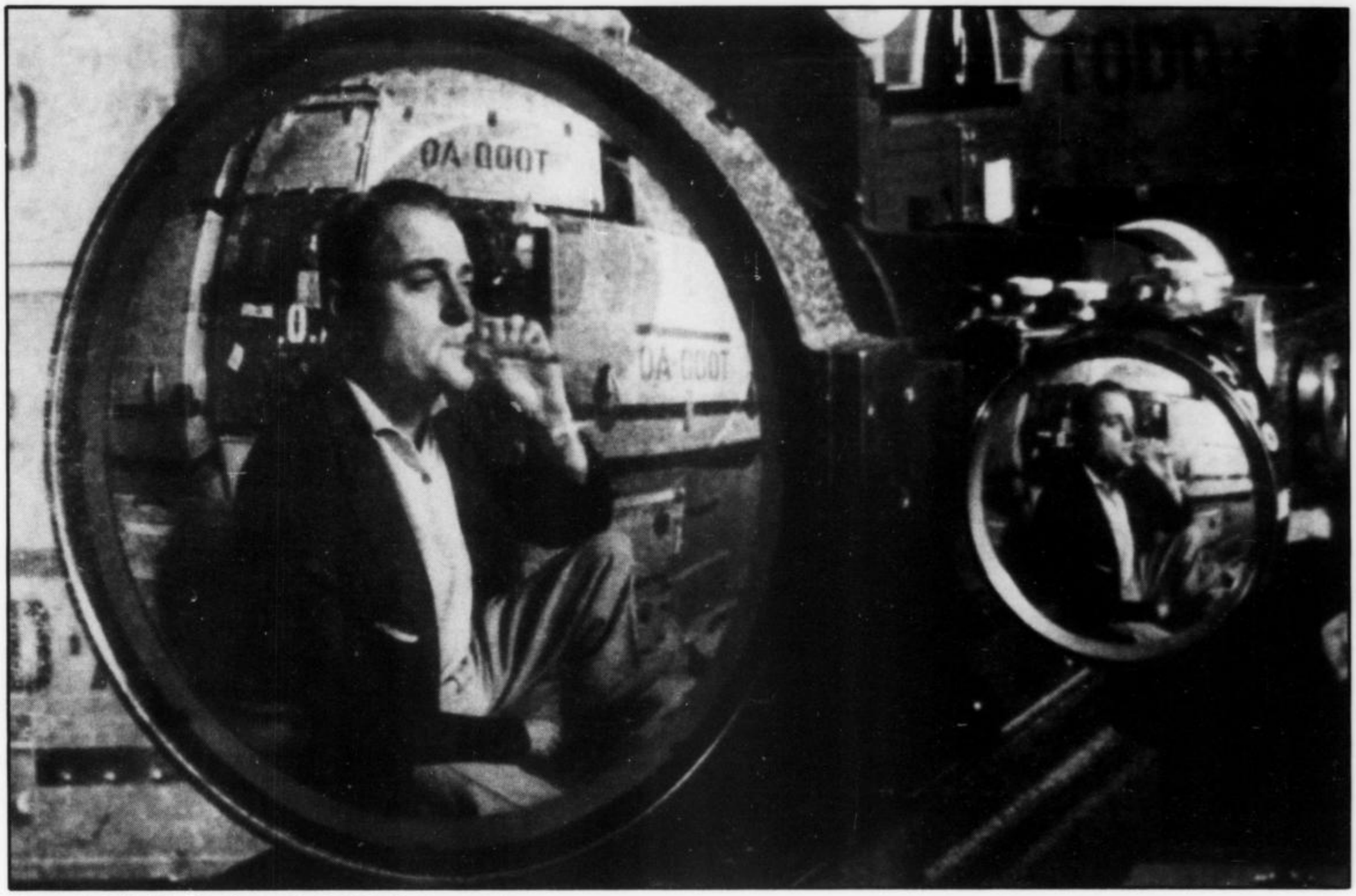


Figure 4. Mike Todd reflected in Todd-AO's bug-eye lens.

use of a lenticular screen, a plastic-coated fabric with an aluminum surface embossed in a formation of lenticles, or tiny lenses, prevented the screen surface from reflecting light back onto itself at the extremities, solving the problem in a somewhat different way, which made it more compatible with traditional screen design.[21]

Deeply curved screens also introduced distortion into the image. Anytime a flat image is projected on a curved screen, the horizontal lines of the image are necessarily distorted. CinemaScope minimized distortion by opting for a slightly-curved screen, a screen which curved at the approximate rate of 1 in./ft, resulting, in the case of a 62 ft wide screen, in a 5-ft curve. The CinemaScope curve compensated for the horizontal expansion of the image, keeping the screen at a more or less constant distance from the center of the projection lens and thus insuring a focus that was as sharp at the edges as at the center.

The use of wide-angle lenses in photography, on which the Cinerama and the Todd-AO relied almost exclusively, compensated somewhat for this distortion, as did Cinerama's use of three separate projection booths,

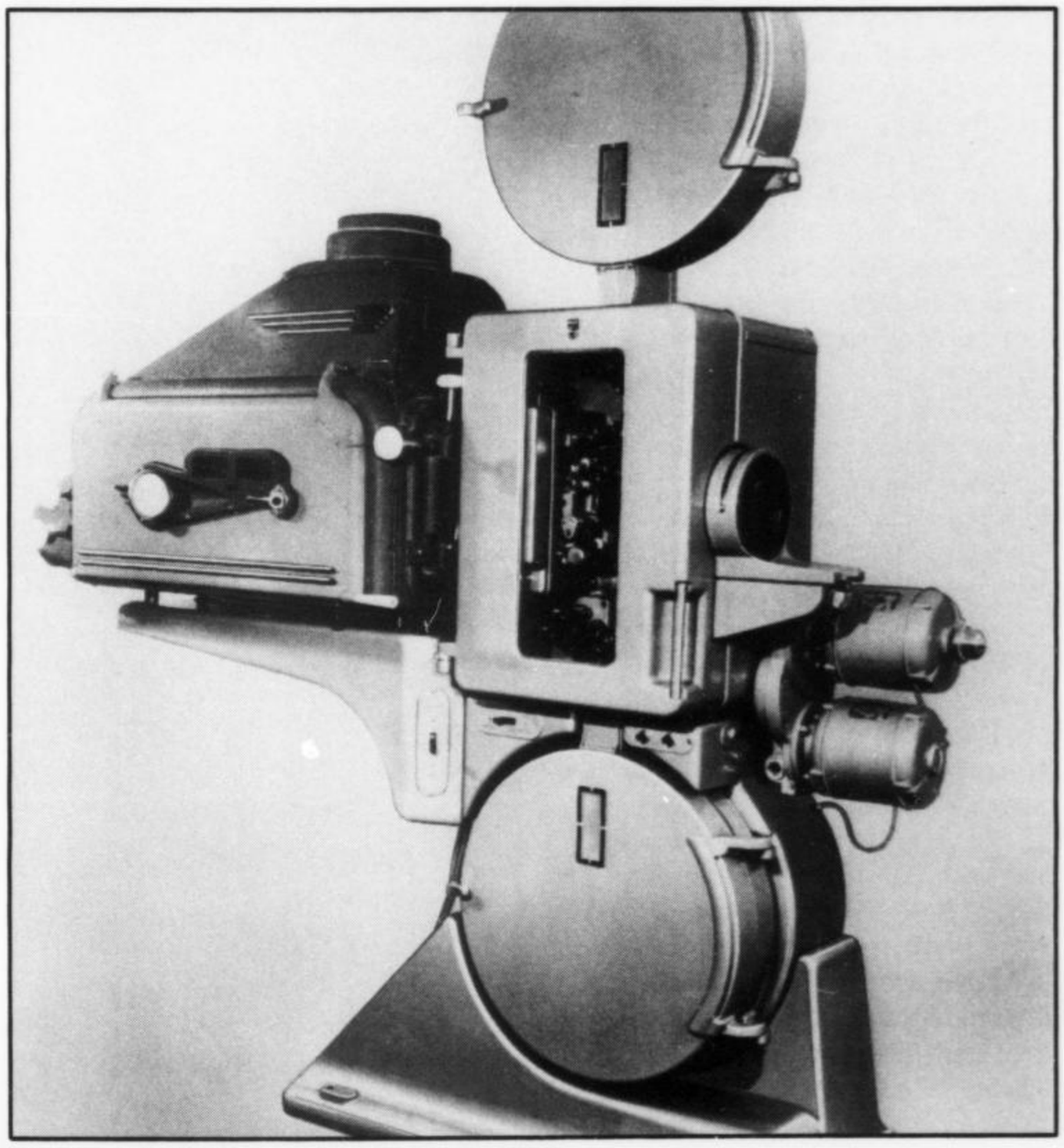


Figure 5. The Philips projector used for Todd-AO.

which facilitated the proper angling of the side booths and made possible more or less head-on projection. The Todd-AO screen, which curved to a depth of 13 ft with a width of 52 ft and a height of 26 ft, threatened to increase distortion, especially under the restrictions of single-booth projection, which eliminated Cinerama's solution to the problem.

Handling Distortion

At the same time, Cinerama's projection system demanded considerable changes in theater architecture. In most cases, three new booths had to be constructed in order to avoid distortion problems introduced by off-angle, balcony projection and to facilitate the three-film projection process. Booths had to be built into the seating area of the theater orchestra, often precipitating the loss of a thousand or more seats. Todd-AO sought to reduce conversion costs by using existing booths. In this way, they could make an installation for about $40,000 which, though more expensive than CinemaScope's conversion cost of $25,000, proved much more economical for theaters than conversion to Cinerama, and provided exhibitors with a system that allowed them to show all existing formats (except for three-strip Cinerama).[22]

Todd-AO's ingenious solution to the problem of distortion was to compensate for it in the printing process by introducing optical distortions into the projection prints. Thus American Optical developed an optical correcting printing process which eliminates distortions in wide films when projected from high angles onto a sharply curved screen.[23] A demonstration of this corrective printing process was given, in 1956, to participants at the 79th SMPTE Technical Conference in New York, where an uncorrected 70mm print of *Oklahoma* was screened together with a corrected print at the Rivoli Theatre, where the projection angle was 22° and the screen curved to a depth of 13 ft.[24]

The chief drawback of this corrective printing process lay in the incompatibility of the deeply curved Todd-AO screen with other widescreen processes, such as CinemaScope, which involved no corrective printing process and were therefore terribly distorted when shown on a Todd-AO screen.

Nonetheless, Todd-AO sought compatibility, in projection, with other systems. Their Philips projector (Fig. 5) was designed to handle standard 35mm film, 3-D, CinemaScope, and 70mm film at projection speeds of 24 or 30 frames/sec.[25] Its two sound heads, a magnetic head built into the upper corner of the projector housing and an optical head in the standard position beneath the picture head (Fig. 6), could play back six-track and four-track magnetic stereo as well as one-track optical sound. A special sound relay rack, designed and built by Altec, facilitated the switching from one sound format to another.

Benefits of Todd-AO

Todd-AO emerged, in comparison with the industry's best widescreen system, CinemaScope, as a process associated with a product that was even more exclusive. It was used, as was Cinerama, to make only one lavishly produced film a year instead of a studio's entire output for the year, as was the case with CinemaScope at Fox. In fact, Todd-AO was used in the production of only 15 films over a period of 16 years.[26] Todd-AO not only duplicated the Cinerama effect, but it did so at about half the cost. Todd-AO's 128°, bug-eye lens provided an angle of view that closely approximated that of Cinerama, which was 145°. The opening shots of Passepartout (Cantinflas) bicycling through the narrow streets of London in *Around the World in 80 Days*, for example, used this lens to exploit the "Cinerama effect," engulfing the spectator within the tight confines of the stone walls of buildings on either side and plunging the viewer into the midst of the diverse movements of surrounding traffic.

Given the increased size of the aperture used in 70mm projection and the increased camera/projector speed, the Todd-AO system also produced an image that was not only

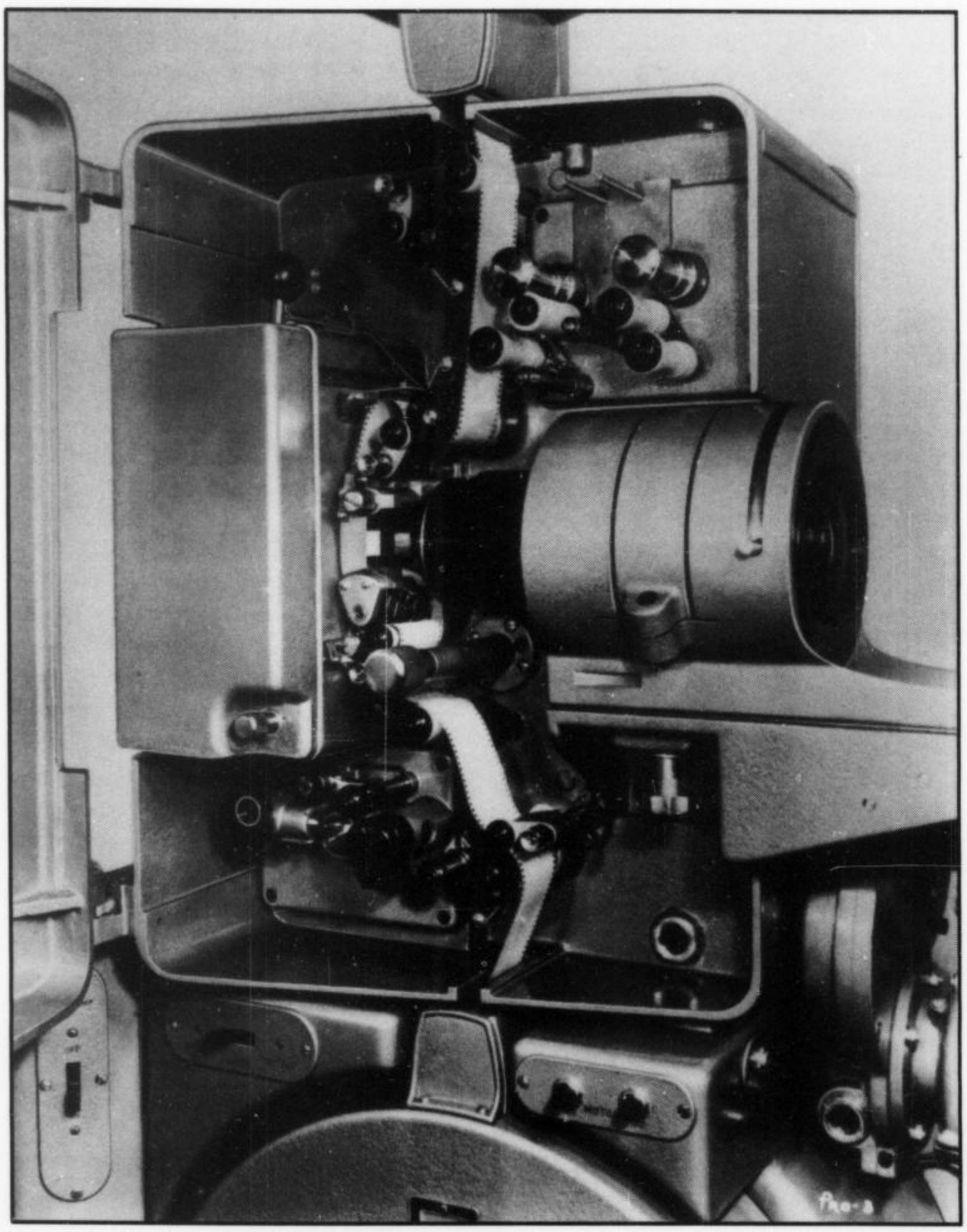


Figure 6. The picture head of the Philips projector.

sharper but brighter. Brian O'Brien anecdotally recalls that the woman with whom he attended the premiere of *Oklahoma* put sunglasses on to watch the picture because the image was so bright.[27]

Like Cinerama, Todd-AO was conceived as a specialized form of entertainment that would be restricted to a finite number of theaters. Though the Todd-AO/Magna Corp. initially projected it would convert 2,000 first-run theaters out of the total of 16,000 theaters nationwide in its first two years of operation, by 1957 there were only 60 Todd-AO installations.[28] This was more than double the number of Cinerama installations at that time, even though Cinerama had a three-year head start on Todd-AO.

Like Cinerama, Todd-AO was based on the notion of the creation of a super-circuit in theatrical exhibition — that is, on the existence of a small number of large, first-run, urban theaters that could afford the $40,000 conversion cost and would be rewarded, in turn, with an exclusive product that would be guaranteed, as a result of the 70mm, multitrack stereo technology, not to play in non-Todd-AO houses until the first-run market had been virtually exhausted. In this way, Todd-AO reinstituted, in a legal way, the system of runs and clearances that had been outlawed as a result of the 1948 Consent Decree (aka the Paramount Case). Indeed, *Oklahoma* ran for over a year in Todd-AO in several cities, rivaling the two-year run of *This Is Cinerama*, before it was released in its 35mm CinemaScope format.

Unlike Cinerama, however, Todd-AO succeeded in converting a good number of the best theaters in the country to show their product, securing more than 60 new installations in its first two years of operation.[29] Todd's partnership with the United Artists Theatre Circuit served to assure the success of the process by providing him with a built-in market (of over 100 theaters located in 50 major cities) for Todd-AO productions. And, since more than half of a film's total income during this period came from first-run exhibition in only a handful of theaters (that is, from approximately 700 first-run theaters in 92 cities), Todd-AO producers realized fantastic profits. So did the stockholders of Todd-AO and of Magna Theatres, who received a combined royalty of 5% of the admission

Figure 7. Filming the roller-coaster effect for a Todd-AO short.

price for each spectator who saw the film in Todd-AO but no royalty for the 35mm CinemaScope release.[30]

Again, like Cinerama, Todd-AO exhibition relied on a theatrical, road-show pattern, scheduling only two or three screenings a day and making tickets available on an advance-sale, reserved-seat basis. Todd's co-partners, Richard Rodgers and Oscar Hammerstein, insisted, as well, that the integrity of the original stage musical be respected and forbade the inclusion of any sensational audience-participation type of screen action, such as the roller-coaster ride used in Cinerama (Fig. 7).[31] This did not, however, prevent Todd and Zinnemann from indulging in a modified Cinerama effect when the camera dollied forward through an enveloping field of corn "as high as an elephant's eye" during the opening "Oh, What a Beautiful Morning" song sequence, or to introduce a roller-coaster-like thrill with a sequence filmed on a runaway carriage. The theatrical quality of the presentation of Todd-AO even extended, in the case of *Oklahoma*, to a ban on the sale of popcorn in the theater.[32]

Todd-AO drew on the theater in other ways as well. Todd, a Broadway producer, launched Todd-AO in collaboration with the Broadway playwright and composer team of Rodgers and Hammerstein, whose theatrical properties provided the basic dramatic material (*Oklahoma*, and *South Pacific*) to be filmed in the system.[33] Even though *Around the World in 80 Days* superficially resembles a Cinerama travelogue, it also has theatrical origins, deriving from Mike Todd's collaboration with Orson Welles on a Broadway version of the Jules Verne novel in the early 1940s.[34] Todd-AO producers continued to ransack Broadway for material, adapting *Porgy and Bess*, *Can-Can*, and *The Sound of Music* for the screen and spearheading a trend in which producers began to draw more and more regularly upon Broadway for material for their big-budget, widescreen spectacles.

The ultimate success of the Todd-AO process can be measured, in part, by the failure of rival systems, such as Fox's CinemaScope 55 and Grandeur (which was revived for their production of *The King and I*), and Fox's own capitulation to Todd-AO, through their acknowledgment that, by 1958 when *Around the World in 80 Days* was experiencing record profits at the box office, "CinemaScope had lost much of its novelty and that customers were no longer drawn to theaters solely because the picture was in the CinemaScope process."[35] In 1958, Fox made an investment of $600,000 in the Todd-AO Corp., securing the right to make pictures in that process, and after Mike Todd's death in an airplane crash later that year, secured control of the Todd-AO Corp. Finally, five years later (just after Todd-AO bought into the Dimension-150 process), Cinerama abandoned its cumbersome three-strip process for Ultra-Panavision's single-strip 70mm system, tacitly acknowledging the technological superiority and economic viability of 70mm as a format and thus following (albeit belatedly) Mike Todd's example in his switch from three-strip Cinerama to 65/70mm Todd-AO. In 1963, for the filming of *It's a Mad, Mad, Mad, Mad World*, Cinerama abandoned its three-strip process for Ultra-Panavision 70, a 70mm system that employed anamorphic optics to squeeze a wide-angle view onto a single film strip and which, when unsqueezed in projection, produced a Cinerama-like image with an aspect ratio of 2.76:1.

Throughout the 1960s, Cinerama continued to compete, though with varying degrees of success, with other wide-film systems, faring well with *The Battle of the Bulge*, *Grand Prix*, and *2001: A Space Odyssey*, and not so well with *The Greatest Story Ever Told* and *Ice Station Zebra*. With the collapse of the Cinerama theater chain (with its deeply curved screens)

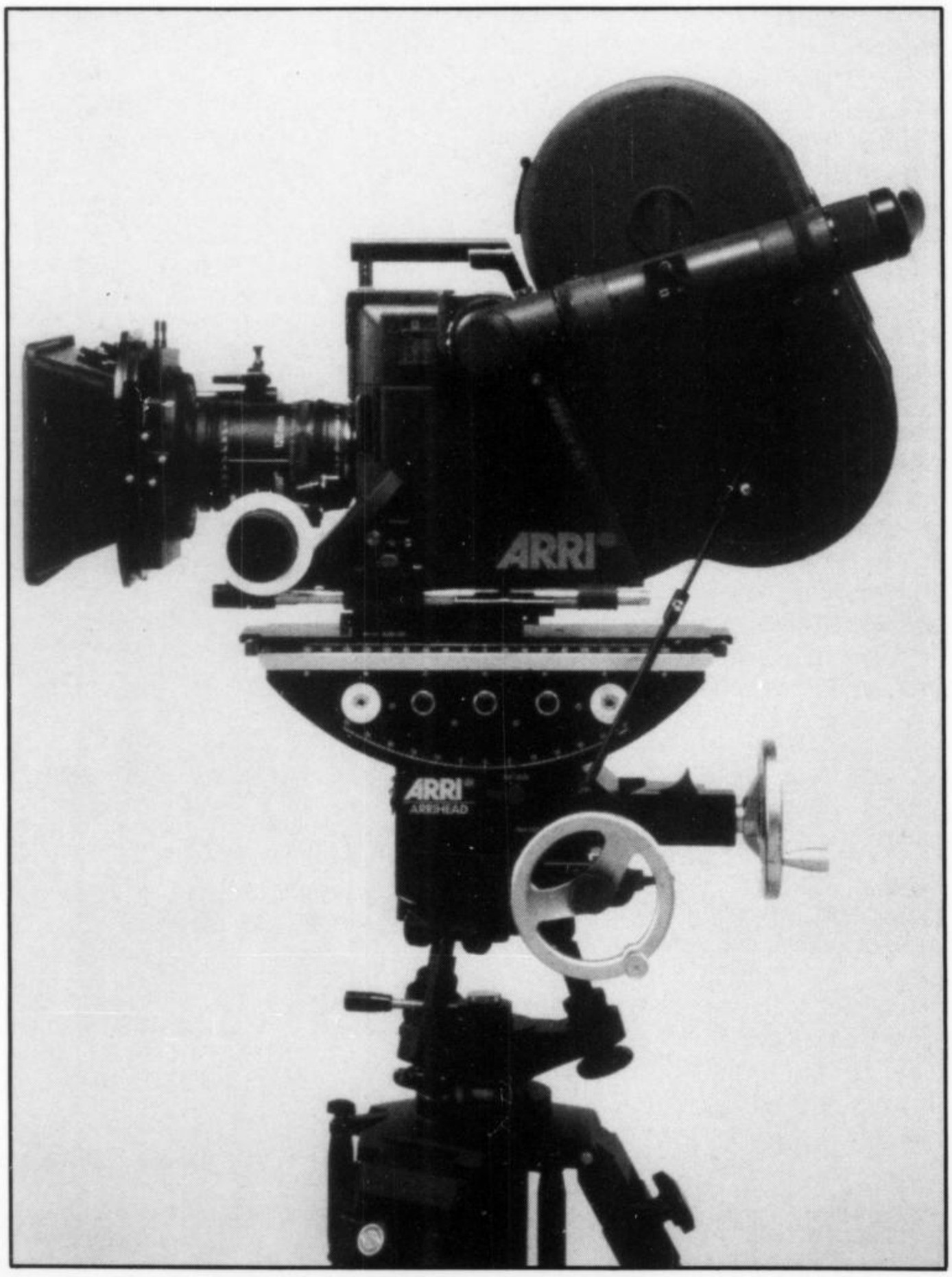


Figure 8. The new Arriflex 65mm studio camera, the ARRI 765.

in the early 1970s, Cinerama became indistinguishable as a presentational process from other wide-film systems and disappeared (though its assets were not liquidated until 1978).

During the 1960s, many first-run theaters around the country screened films exclusively in 70mm. However, the motion-picture marketplace had taken its toll on 70mm production as well. The expense of filming in 65/70mm has, since the early 1960s, resulted in the gradual elimination of original production in 70mm. In 1963, Panavision's Robert Gottschalk introduced an optical system that enabled producers to blow 35mm film up to 70mm for purposes of theatrical road-show exhibition, virtually pulling the rug out from under wide-film production.[36] Now, any 35mm film could be blown up to 70mm for road-show presentation without the expense involved in wide-film production.

Since then, fewer than 30 films have been shot on wide film and more than 230 have been shot in 35mm and blown up to 70mm for first-run exhibitions.[37] The films that have been blown up range from 35mm anamorphic productions (*The Cardinal*, *Dr. Zhivago*, *Close Encounters of the Third Kind*, *Star Wars*, *Apocalypse Now*, and *The Untouchables*) to 35mm, flat, 1.85:1 productions (*E.T., the Extra-Terrestrial*, *Gremlins*, *Back to the Future*, *The Color of Money*, and *The Last Temptation of Christ*), resulting in blow-ups which crop the edges of the former and necessitate the addition of black masking along the sides of the latter.[38]

Though curved screens are no longer exhibition standards and although extreme, wide-angle, bug-eye lenses find infrequent use within contemporary filmmaking practice, the 70mm format, which the Todd-AO process successfully introduced in 1955, remains with us today, as does the notion of an exclusive circuit of motion-picture theaters that can provide audiences with a motion-picture experience which cannot be duplicated by contemporary 35mm exhibition. Within the past few months there has even been some movement within the industry back to 65mm as a production standard with the introduction by Arriflex of their new, extremely quiet (25-dBA), state-of-the-art 65mm studio camera, the ARRI 765 (Fig. 8). At the same time, Panavision announced its own updated 65mm camera.

The Future of the 70mm Format

A recent study conducted by Wilkofsky Gruen Associates for Merrill Lynch predicts that by 1995 the sale of prerecorded videocassettes will reach the 700 million per year mark, accounting for over $14 billion in revenues. In addition to this, another $6 billion will be realized in video rentals, adding up to a total of $20 billion. At the same time, based on recent statistics for theater admissions, they predict that motion picture box offices will take in revenues of only $8 billion. In other words, the video revenues of a motion picture will more than double its box office gross.[39] The only force within the marketplace that might reasonably retard this process, bringing audiences back into movie theaters, is the experience of 70mm coupled with stereo sound, an experience which can never be fully duplicated in the home. The answer to the future of the motion-picture industry, especially to that of theatrical exhibition, might just lie in the past, in the example of excellence set by Todd-AO in the 1950s.

Notes

1. Statistics courtesy of Dolby Laboratories, Inc., as of March 24, 1988.
2. Gio Gagliardi, *Motion Picture Herald*, August 6, 1955, 14.
3. Gagliardi, *Motion Picture Herald*, 15.
4. *Daily Variety* (April 29, 1953): 3.
5. *Daily Variety* (February 2, 1953): 10.
6. *Daily Variety* (March 3, 1954): 6.
7. *Time* (June 8, 1953): 66.
8. *Daily Variety* (October 15, 1952): 4.
9. Lorin Grignon noted considerable optical distortion in his report to Fox on the process (dated October 14, 1952). He wrote that "The distortions of Cinerama are such that the ordinary interior does not look natural but there are circumstances where the distortion of scenes is of little apparent consequence, for example, the church interior. However, in this particular sequence the change in the shape of the steps is apparent as the camera dollies in." He also noted horizontal distortion; it was "as though the floor is bowl-shaped. . . people or moving objects appear to go up the sides of the bowl. This is particularly noticeable in the opera scene." Sponable Collection, Box 117, Cinerama folder.
10. Grignon memo to Sponable dated October 14, 1952.
11. Letter to the editor from Laurence J. Roberts, *American Cinematographer* (December 1983).
12. New York *Times* (October 5, 1952). As late as May of 1960, *American Cinematographer* noted that "closeups of people shot with Cinerama cameras show typical wide-angle close-up distortion. Noses appear very long and foreheads slant back. Ears are very small in proportion and chins recede. (304)"

    Early CinemaScope, which employed an anamorphic lens that was unable to focus clearly at distances under 4 ft from the camera, faced a somewhat different problem involving not distortion but sharpness of focus. However, though extreme close-ups remained difficult to achieve in CinemaScope, standard close-ups were easily accomplished.

    Three-strip Cinerama was ultimately used to film narratives, such as *The Wonderful World of the Brothers Grimm* and *How the West Was Won*, but narrative information was conveyed in these films without the use of close-ups, relying on narrative techniques borrowed from the theater (and which CinemaScope had earlier drawn upon).
13. They were *This Is Cinerama* (1952), *Cinerama Holiday* (1955), *Seven Wonders of the World* (1956), *Search for Paradise* (1957), and *South Seas Adventure* (1958).
14. Michael Todd, Jr., and Susan McCarthy Todd, *A Valuable Property: The Life Story of Michael Todd* (New York: Arbor House, 1983): 219.
15. Ibid, 245.
16. Though Todd-AO lenses were generally classified in terms of angle of view rather than focal length, their focal lengths were given as follows: 128° (22mm), 64° (44mm), 48° (58mm), and 37° (76mm).
17. Quoted in a report on the "Magna Theatre Corporation" for Twentieth Century-Fox by Harris, Upham & Co. (December 2, 1953). Sponable Collection, Box 120.
18. A 35mm, Technicolor, four-track magnetic stereo, CinemaScope version of *Oklahoma* is on deposit at the UCLA Film Archives. The CinemaScope version was released to non-Todd-AO houses after the wide-film version had completed its initial run.
19. *Motion Picture Daily* (October 7, 1955): 12.
20. Arthur Rowan, "Todd-AO — Newest Wide-Screen System," *American Cinematographer* (Oct. 1954): 495.
21. *Motion Picture Herald*, 15.
22. *Daily Variety* (Oct. 26, 1956). *Variety* notes that Todd-AO conversion costs were cut to $20,000 by October of 1956.
23. *Film Daily* (May 2, 1956).
24. *Film Daily* (May 2, 1956). Todd-AO claimed that this system could accommodate projection angles as great as 25°. See *Film Daily* (October 26, 1956).
25. The projector could handle 70mm film with any number of magnetic tracks; 70mm with a separate magnetic sound track; CinemaScope with four-track magnetic sound; CinemaScope with optical or Perspecta Sound; standard 35mm film; single-strip 3-D; and double-strip 3-D.
26. Robert E. Carr and R. M. Hayes, *Wide Screen Movies* (Jefferson, N.C.: McFarland, 1988): 187–188.
27. Dr. Brian O'Brien, in telephone conversation with the author, Nov. 1988.
28. Harris, Upham & Co., "Magna Theatre Corporation" report, dated 2 December 1953, Sponable Collection (Columbia University Libraries), Box 120, Todd-AO General folder. Also *Motion Picture Daily* (20 December 1957).
29. Sponable Collection, Box 120, "Todd-AO/TCFF Corp." folder, Columbia University Libraries.
30. The Sponable Collection, Box 120, Todd-AO-Twentieth Century-Fox Film Corp., 1959–60, Contracts.
31. *Film Daily* (May 2, 1956).
32. Reported by James Limbacher in his *Four Aspects of the Film* (New York: Brussell and Brussell, 1968).
33. Other Rodgers and Hammerstein properties, such as *Carousel* and *The King and I*, had already been contracted to Fox and were filmed there in the wide-film process of CinemaScope 55.
34. Barbara Leaming, *Orson Welles* (New York: Viking Penguin, 1985): 395–401.
35. Internal Fox memo by Donald A. Henderson on "The Todd-AO Matter" (September 16, 1963), Sponable Collection, Box 120.
36. Douglas Trumbull, in conversation, October 14, 1988.
37. Hayes and Carr, *Wide Screen Movies*, pp. 187–189; 200–206.
38. The anamorphic image, which has an aspect ratio of 2.35:1, does not quite fit on a 70mm frame, which is roughly 2.21:1, thus requiring cropping. A 1.85:1 image doesn't quite fill the 70mm frame, which must then be masked. For an excellent discussion of blow-ups, see Carr and Hayes, pp. 196–206.
39. Bob Brewin, "VCR's: Bigger Than Box-Office," *The Village Voice* (March 11, 1986): 45.

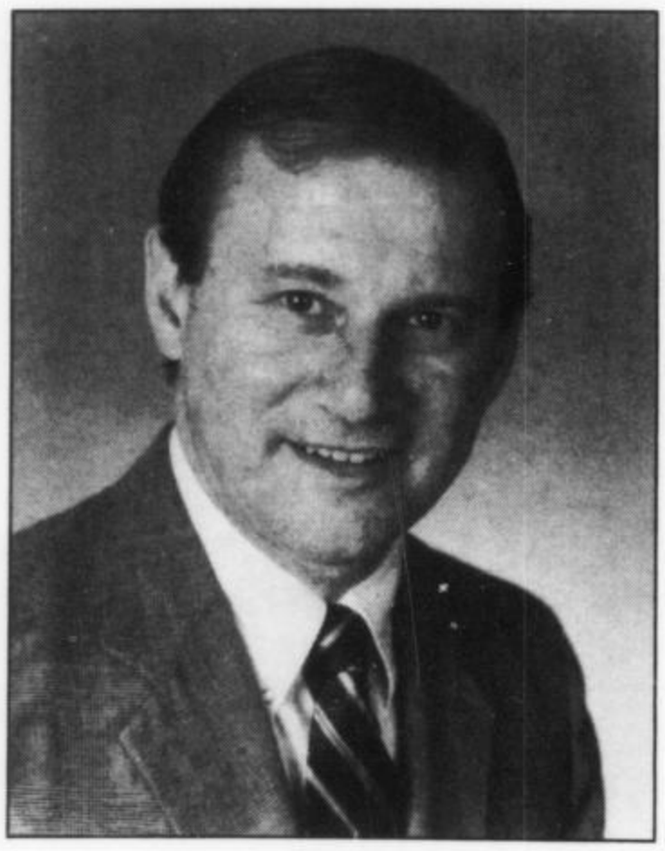
Biographical Sketch

Stanley N. Baron, Engineering Vice-President, 1989–1990

If your work assignment also happens to be a labor of love, then you are lucky enough to have found a job that you can thrive on. SMPTE Engineering Vice-President Stanley N. Baron (NBC) is among those who are fortunate enough to have a career that quenches a thirst for knowledge and indulges a joy for learning.

Baron's passion for electronic engineering began at the age of 10, when he started building radios. After 25 years in the industry, that passion continues to flourish. He still enjoys the excitement of investigating new technologies and finds gratification in their practical applications. His enthusiasm is fueled by his position as managing director, technical development, NBC, where he is responsible for the investigation and application of new technologies, and by his role at SMPTE, where, as part of a larger group, he works toward the common goal of industry standardization.

"I enjoy my work. It lets me face a variety of activities each day," Baron said. "There are challenges in both dealing with my day-to-day work environment and the SMPTE efforts on standardization issues and practical aspects of the limitations and applications of HDTV."



Stanley N. Baron

Special Interests

Baron said that he finds his area of specialization, digital technology as it applies to imaging, to be a particularly fascinating field of electronics because it lets him manipulate information in ways that were not possible before. "It also allows me to create images that don't even exist in real life. With digital imaging I can synthetically generate an image of something that exists purely in my head. A camera allows me to capture the real world, digital imaging lets me demonstrate what is not real."

His interest in that field was piqued during his college years at New York University (NYU) when he took a course that focused on computers. "I loved the aspect of working with the digital representation of the real world as it provides a higher level of precision," he said.

After graduating from NYU with a B.S.E.E. and M.S.E.E., Baron joined General Electric Co. (GE) where he applied his knowledge and energy to the design of digital processors for synthetic video generation. During his second year at GE he was given a solo assignment of designing a digital computer.

Later, he took a position with CBS Laboratories, where he continued to work on digital computer design and synthetic video generation. "Digitization can be applied to television in two ways," he explained. "It can be used in the area of graphics or for synthetic video generation, and it can also be applied to video processing."

Inventions and Patents

While at CBS, Baron received a patent for Vidifont, a graphics quality proportional titling generator for television use. The first of several patents he has received, Baron still considers that moment to be one of the highlights of his career. "The Vidifont simplified the graphics arts procedure by allowing immediate generation of titles, replacing a slow and ponderous film and imaging scanning system," he said. "The real contribution was that it relieved the graphic artist of a dull, tedious job while at the same time reducing the cost of production." During his seven years at CBS, Baron also developed other digital graphics generators and made contributions to video processing technology.

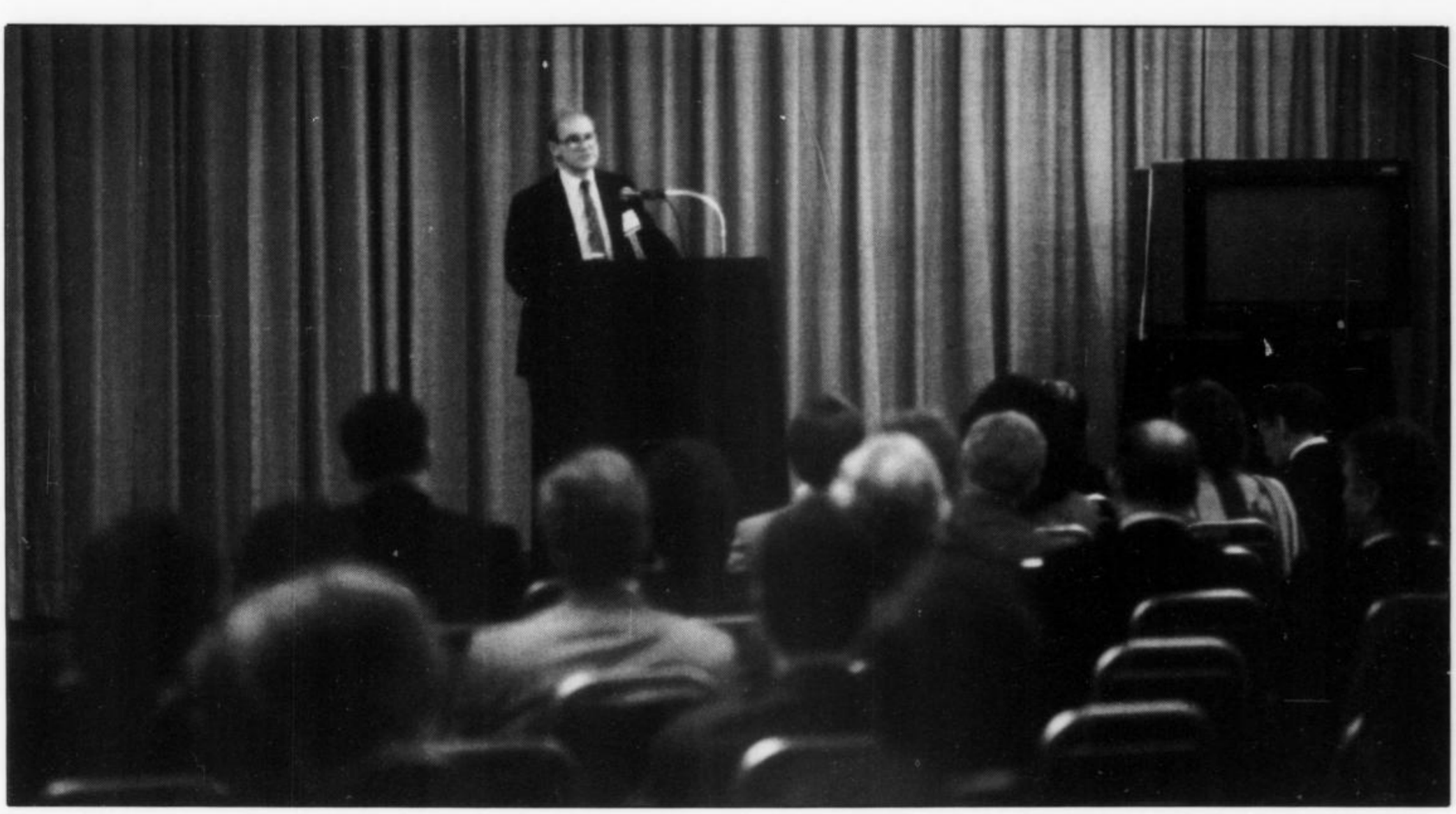
After holding positions at other companies, Baron went to work for Thomson-CSF Broadcast, following its purchase of a part of CBS Laboratories. He returned under the direction of Renville McMann, whom he had worked for while at CBS. At Thomson, he was involved in yet another fulfilling project — the design of a life-saving medical imaging device. The result was the co-invention of an adaptive temporal video processor used in performing noninvasive intravenous angiography.

Baron joined NBC in 1985, as managing director of technical development. He explained that this position allows him to use the gamut of his engineering experience. "The assignment at NBC has been very worthwhile. I have been involved in a broad range of issues, including the entire video chain from the gathering of images at the camera, through recording, processing, and automation of that process. While a certain amount of effort is expended on advanced television or HDTV issues, I also have enough contact with the everyday world to keep myself firmly grounded in reality."

The SMPTE

Baron gets great satisfaction from his position as Engineering Vice-President of the SMPTE. "It is an extremely worthwhile feeling to be part of a larger organization that is working towards a common goal," he said.

"There are over 600 volunteers in the Society working on various committees. We have to work very hard to make sure there is an even playing field for everyone to work on and that everyone has an opportunity to be heard."



Baron delivering an engineering report during the opening ceremonies of the 131st SMPTE Technical Conference and Equipment Exhibit held in Los Angeles.

However, the position is not without its challenges. "We are dealing with the problems and issues of setting standards. There are over 600 volunteers in the Society working on various committees. We have to work very hard to make sure there is an even playing field for everyone to work on and that everyone has an opportunity to be heard. There are a lot of different forces at play and the position takes time and energy."

Baron, who just started his second term as Engineering Vice-President, said that the job has also been a good learning experience in that he has developed a greater appreciation for film as a medium. He also gave kudos to Roland Zavada, who served as SMPTE Engineering Vice-President from 1975 to 1983. "This is a voluntary job that should not be taken casually. Roland Zavada demonstrated what must be done in order to do this job properly."

An SMPTE member since 1977, Baron has played a key role in the development of SMPTE standards for digital video, serving as a member of the Working Group on Digital Video Standards since he joined the Society. He is also active in many other of the Society's arenas, including its Board of Governors and Long Range Planning Committee.

In looking toward the future of the industry, Baron firmly believes that the SMPTE is in a position to continue providing quality leadership in imaging standards. "All of the imaging technologies are coming together, and there is a certain amount of commonality in both film and electronics," he said. "The world is changing, and we have to make an effort to prepare the Society for its future role."

Background

A native of Connecticut, Baron was born and raised in Norwalk. After graduating from Norwalk High School, he completed his education at NYU, where he met Connie, his wife of 27 years. Mrs. Baron has an M.S.W., and her work involves placing retarded adults in work situations. The Barons are the parents of three sons, Matthew, 25, Jon, 22, and Andrew, 21.

Although he has little time for leisure, he enjoys running and bicycling. However, he is currently recuperating from a running accident, and plans to devote more of his energies toward biking.

Professionally, his many accomplishments include writing or co-authoring more than 50 articles and papers, and he has lectured extensively, both at home and abroad. His professional affiliations include membership in the Royal Television Society and the IEEE. In addition, he serves as a member of several European Broadcasting Union committees.

—Carol King

The skyline and the Brooklyn Bridge are among the sights to be seen in New York City.

The 132nd SMPTE Technical Conference and Equipment Exhibit

Javits Convention Center, New York City, October 13–17, 1990

In preparation for the educational portion of this year's SMPTE Technical Conference and Equipment Exhibit, the Program Committee has been appointed, it was announced by Program Chairman Kerns H. Powers (consultant).

The committee members are Furn D. Anderson (HBO), David A. Elliott (ABC), John W. Erwin (Eastman Kodak Co.), Alan S. Godber (NBC), Jukka Hamalainen (Matsushita Applied Labs), Mark Schubin (consultant), and Timothy J. Spitzer (Du Art Video). "One or more topic areas will be assigned to each committee member," Powers said. "The committee will also develop a plan for the review and selection of papers in each topic area." Powers expects that papers submitted to the committee will cover a wide range of subjects, including TV production, TV post-production, film production, laboratory and technology, film/electronic interface, computer graphics, ancillary services, video measurements, recording, sound, automation/robotics, and advanced television.

The deadline for submitting papers is June 15, 1990. Authors will be notified prior to August 3 if their papers have been accepted for presentation. Completed manuscripts are then due back at SMPTE headquarters by August 13 so that the papers can be preprinted and sold at the conference. Selected manuscripts will also be considered for publication in the *SMPTE Journal*.

"Film and Television — One World?" is the theme of the conference, which will be held October 13–17, 1990, at the Jacob K. Javits Convention Center in New York City. Additional information on the conference or the educational program can be obtained by writing to Marilyn Waldman, Program Coordinator, SMPTE, 595 W. Hartsdale Ave., White Plains, NY 10607, or by calling her at (914) 761-1100.

A number of companies have already committed to display their products at the equipment exhibit. Ultimately, it is expected that 250 to 300 manufacturers will participate.

Conference Highlights

The conference will offer entertainment as well as education. General Arrangements Chairman Charles Jablonski and his committee are planning a full schedule of activities to complement the technical program and equipment exhibit. There will be a Welcoming Reception at the Marriott Marquis Hotel on Friday, October 12, an Honors and Awards Luncheon at the convention center on Saturday, October 13, and a Fellows Luncheon at the Marriott Marquis on Sunday, October 14. The Annual Banquet will be held at the Marriot Marquis on Tuesday, October 16.

In addition, a full Spouses Program is being organized by Patricia Spicer. Her plans include historical tours, elegant luncheons, and designer shopping sprees that will feature discount prices. "We plan to see all of New York City, from Tribeca to Soho to the exquisite new Battery Park City, going all the way up to the very elegant, northernmost parts of Manhattan," Spicer said.

Registration Packages

Blocks of rooms have been set aside for conference attendees at the Marriott Marquis, which will serve as the headquarters hotel. Rooms are also available at the New York Hilton Towers and the Sheraton Centre and Towers.

—Carol King

SMPTE Participates in NAB Convention

March 31–April 3, 1990

The SMPTE booth at the 68th National Association of Broadcasters Convention in Atlanta welcomed many visitors during the four-day event, held March 31–April 3, 1990, at the Georgia World Congress Center in Atlanta.

At least 60 new members joined the SMPTE at the NAB convention, while many current participants stopped by and renewed their memberships. In addition, numerous orders were taken for the Society's new book, *Television — Merging Multiple Technologies*, which was displayed at the booth. The book contains 27 presentations that were given at the 24th Annual SMPTE Television Conference held in Lake Buena Vista, Fla. last January, as well as two additional papers.

Representing the SMPTE from headquarters were Executive Director Lynette Robinson, *Journal* Editor Jeffrey Friedman, Director of Engineering Sherwin Becker, Assistant Conference Manager Anne Cocchia, and Staff Engineers Mark S. Hyman and Fred Galli. SMPTE Officers and Governors also attended the show.

During the convention several SMPTE engineering committees met: the Study Group on Applications of Optical Disc Technology, the Subcommittee on Digital Control for Television, the Working Group on Editing Procedures, the Ad Hoc Group on Digital Representation of 1125/60, the Study Group on Fiber Optic Applications, and the Working Group on Studio Monitors.

The equipment exhibit at the 1990 NAB Convention.

Total attendance at this year's NAB Convention was 50,443, breaking all previous records. International attendance stood at 6,000. There were 750 exhibitors in 430,000 sq. ft. of floor space.

Highlights at this year's convention included a special industry address by President George Bush, a state-of-the-industry address by NAB president and CEO Edward O. Fritts, a presentation by Al Sikes, chairman of the FCC, and a special luncheon speech by Donald Keogh, president, Coca-Cola. In addition, Charles Osgood and Hal Jackson were inducted into the Broadcasting Hall of Fame as were the cast members of the television classic, "The Honeymooners" and former NBC president Sylvester "Pat" Weaver.

During the educational portion of the convention, approximately 40 members of Congress participated in sessions to discuss cable deregulation, radio legislation, campaign election reform, telephone company entry into video services, and the future of beer and wine advertising. Also, special sessions on international broadcasting were held, discussing the changing economic climate in Europe and the opportunities for investment around the world.

—Carol King

ON THIS LEVEL-TWO WEST...
• RADIO SESSIONS
• LEGAL REGULATORY ROUNDTABLES
• W265-RECEPTIONS/SPECIAL SESSIONS
ESCALATOR DOWN TO LEVEL ONE WEST

More than 50,000 people attended the 1990 NAB Convention in Atlanta.

The 25th Annual SMPTE Television Conference

Westin Hotel, Detroit, Michigan

February 1–2, 1991

A Call for Papers has been issued for the upcoming 25th Annual SMPTE Television Conference by Editorial Vice-President Frank J. Haney, Capital Cities/ABC, and Program Chairman Rudolph J. Kryger, CBC.

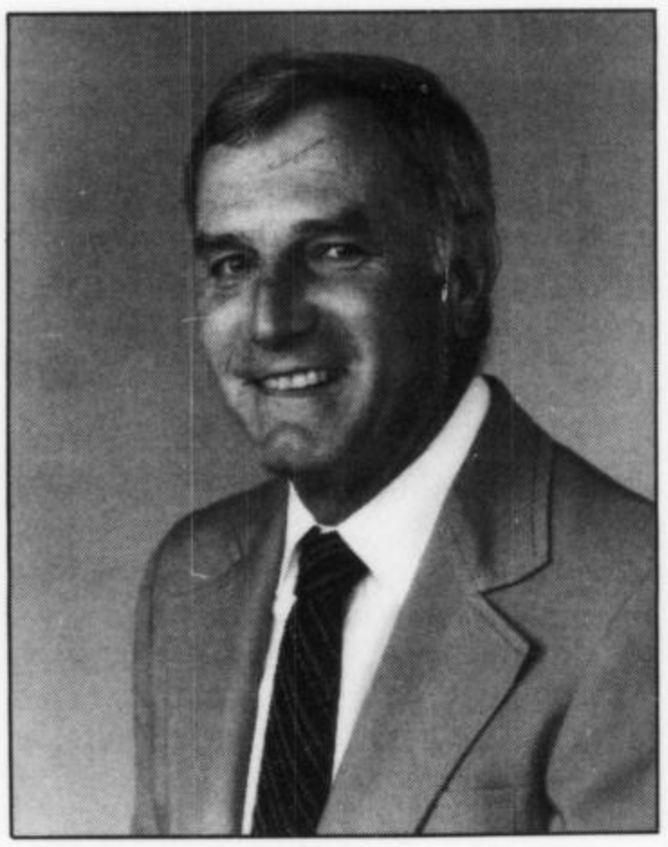
"The theme of the conference is A Television Continuum — 1967 to 2017. We plan to focus on the progress made in television technology over the past 25 years, as well as take a subsequent look into the future," said Kryger. "For the majority of papers and presentations, we will be dealing with present-day technologies. However, we will also look into papers that contain futuristic yet practical concepts, and papers with crystal-ball-like predictions spanning the next 25 years."

The Conference Program will be divided into several sessions. It will kick off on Friday, February 1, with "A Path to the Future," a session comprised of no more than two papers that present a review of the past 25 years of television technology. The second session, "Forward to the Present," will highlight technologies and their status, including HDTV standards, EDTV methods, and digital recorders. Saturday's sessions will begin with "Back to the Future," which will continue the coverage of present technologies, as well as offer presentations on the newest industry concepts. "Crossroads to the 21st Century," which will focus on future developments and predictions, will close the program.

Paper Submission Information

For a technical paper to be considered for the conference, authors should send their name, company affiliation, address, telephone number, and a 500-word synopsis to SMPTE, Attn: Marilyn Waldman, Program Coordinator, 595 W. Hartsdale Ave., White Plains, NY 10607, by September 14, 1990. The information should be submitted on forms which are available from headquarters.

Program Chairman Rudolph J. Kryger



Editorial Vice-President Frank J. Haney

Authors will be notified of the acceptance of their papers prior to October 15, 1990. Finished manuscripts of accepted papers are due back at Society headquarters by January 7, 1991. They will be compiled and published in a book and will also be considered for publication in the *SMPTE Journal*. SMPTE members and nonmembers alike may present papers. Presentations usually last about 20 minutes.

Additional information may be obtained by writing to the Program Coordinator at the address above or by calling (914) 761-1100.

Committee Chairmen Appointed

Several Program Committee Chairmen have already been appointed. Frederick M. Remley, University of Michigan; John F.X. Browne, John F.X. Browne and Associates; and Keith P. Neff, Grace & Wild Studios, will serve as Topic and Session Chairmen. In addition, Kenneth P. Davies, CBC, will serve as a Topic Chairman and Esio J. Marzotto, University of Windsor, will be a Session Chairman. Stan Nalski, Filmcraft Lab Inc.; H. Chris Hill, Archdiocese of Detroit; and Harold L. Miller, Technicolor Video, will serve as Session Co-chairmen. Leonard W. Eden, John F.X. Browne and Associates, will be General Arrangements Chairman.

Conference Highlights

The 1991 Television Conference will offer a mixture of educational opportunities. In addition to the traditional paper presentations, there will be a joint session in conjunction with the Audio Engineering Society (AES), where a mixture of papers from both the SMPTE and AES will be presented.

In addition, there will be a seminar offered on January 31. "On the day before the conference begins, we will offer an all-day tutorial, similiar to that offered at last year's Television Conference held in Lake Buena Vista, Fla.," Kryger said. "This educational opportunity is intended to bring people up to speed with the newest events occurring in the industry."

—Carol King

Section Meetings

Hollywood, March 20, 1990 — A presentation on video effects featured Bill Taylor (A.S.C.) and Syd Dutton, Illusion Arts, and Doug Smith, Apogee, Inc. Using film clips to demonstrate the before and after of matte paintings, miniature models, and motion-control photography, the trio showed the 250-member audience new techniques used in features such as *Star Trek V*, *Karate Kid II*, and *Coming to America*. The meeting was held at the Hitchcock Theater at Universal City Studios. SMPTE Governor Lou Wolf provided the theater for the Section meeting. — Milton R. Shefter (Secretary/Treasurer), Paramount Pictures Corp.

Houston, March 14, 1990 — Student productions and media programs were shown at the second annual Higher Education Showcase during the Houston Section's March meeting. Representative productions and descriptions of media programs taught at Trinity University, Sam Houston State University, and the University of Houston were featured. Sample clips included dramatic scenes, interviews, music videos, computer graphic openings, a magazine segment on bicycle racing, and a public service announcement on drinking and driving. The hit of the evening was a Claymation production, *Jack and the Beanstalk II*, produced by John Aden and John Streeter, University of Houston.

The meeting, held at the University of Houston, was attended by 25 people. Presentations by Dr. Suzanne Williams, Trinity University, and Dr. Robert Musburger, University of Houston, and tours of the school's film, audio, and video facilities rounded out the meeting. — Robert Musburger (Secretary/Treasurer), University of Houston.

Montreal/Quebec, March 13, 1990 — The use of a new digital video terminal, developed by Videoway and ACTV, their American partner, was the subject of the March Section meeting. Videoway and Videotron Plus are the first to broadcast interactive television through existing cable television networks. They presently broadcast 12 hours a day of interactive programming ranging from game shows, sporting events, live performances, and children's shows. Videoway is already exporting this technology to England where over one million homes are expected to benefit from this service within the next five years. The audience, which was limited to 45 people due to the size of the facility, was mesmerized by the new technology. The meeting was held at Videoway. — Rene Villeneuve (Chairman), CBC.

Nashville, November 29, 1989 — The Nashville Section's November meeting focused on the Ikegami HK-327 studio camera. Thom Calabro, Ikegami Electronics, talked about the camera's design and development. He said that it was designed for the highest picture quality and operability, with very few, if any, compromises. Fixed pattern noise, moiré, blemishes, and aliasing problems are ruled out. The camera utilizes the XQ3510 mixed field Plumbicon which is designed for a 16:9 aspect ratio and provides improved corner resolution in NTSC. The tube also offers magnetic focusing and electrostatic deflection. For improved operability, the camera has a lower center of gravity and a very low optical center. A skin detail feature allows specific detail enhancement, such as the softening of crow's feet in the talent's face. A soft detail feature reduces detail in highlights or lowlights.

Butch Smith, The Nashville Network (TNN), discussed the decision-making process that TNN used in selecting the camera. He said that the station wanted to maintain its high-quality picture without compromising resolution and signal-to-noise. He added that TNN's old TK-45s were running 52 to 53-dB signal-to-noise ratio, and the HK-327s measured 62.8 dB on the worst, and 63.7 dB on the best. This is unweighted signal-to-noise as measured on the Tektronix VM-700. He described custom modifications to the intercom and black stretch circuits. Following the presentations, the 28 attendees were given a tour of TNN, where the meeting was held. — Gene Parker (Secretary/Treasurer), WKRN-TV.

Nashville, February 15, 1990 — Film Now and in the Future was the topic of the February section meeting. Kathy Mazza, Eastman Kodak Co., began the program with a review of papers presented at the SMPTE fall conference. She then narrated a slide presentation entitled "Integrating the Technologies," which was followed by a discussion on some of Kodak's new developments, including the EXR color negative films and Keycode numbers for 16mm and 35mm films.

John Johnston, Eastman Kodak Co., spoke on the future of film in the era of HDTV. He discussed high-resolution images in video and the potential of film in terms of its resolution possibilities. He said that the needs of the HDTV industry should be met by integrating the best of both video and film technologies, noting that every new advancement in film is contained within the film product, whereas electronic advancements require new hardware. He then talked about the experimental high-performance HDTV telecine that was recently announced by Kodak. It is the product of a partnership between Kodak and Rank Cintel that uses two new linear array sensors, a xenon light source, and a high-speed digital processor. He also discussed Kodak's new Keycode system.

Following his presentation, a film commemorating 100 years of the motion-picture industry, *Pieces of Silver*, was shown. Also, a film demonstrating Kodak's new 7248 color negative film and a film made by Grenada Television on 7425 daylight negative film were presented. The meeting was held at United Methodist Communications, and the 34 attendees toured the facility at the end of the program. — Gene Parker (Secretary/Treasurer), WKRN-TV.

Nashville, March 22, 1990 — Digital audio production with the Synclavier was discussed by Hollis Hoffer and Matt Morris of Aesophagus Press. Hoffer defined the Synclavier as a "word processor of musical sounds" and talked about the

Attendees observe a playback of a student production at the Houston Section's Annual Higher Education Showcase held during the March meeting.

various storage media, stating that "an 80-Mbyte Winchester disk equals 80 seconds of recording time. The music tower contains 16 Mbytes of ROM, 32 voices, 200 tracks, and has a 450-note capacity. It has a MIDI interface and can hold 5½ hours of storage on an optical disk." The Synclavier allows for nonvolatile editing, as compared to editing tape and a razor blade. The post-production system provides for a universal transfer in the digital domain between various digital signals. He then demonstrated how the product sound effects can be matched to a video through the use of a time code with several videotapes that were controlled by the Synclavier.

Morris then discussed the Synclavier from a composer's standpoint. It has a 200-track sequencer and 2.1 Gbytes of storage on an optical disk. He then provided a demonstration using two Synclaviers linked together, controlling a synthesizer. A cymbal sound was analyzed and modified.

The meeting, which was held at MPL/Postmasters, was attended by 18 people. Following the presentations there was a question-and-answer session and a tour of the facility. — Gene Parker (Secretary/Treasurer), WKRN-TV.

Pasadena City College Student Chapter, March 13, 1990 — Diana Weynand and Shirley Craig, Weynand Associates, explained their role in providing specialized training for people in the video and film industry. They shared with the Section members copies of company-produced books and workbooks that cover computerized videotape editing, videotape operations, post-production, and news editing. Interior shots of various control rooms and edit bays were illustrated via chalkboard illustrations and 35mm slides. The pair also gave tips on getting a job and working in the network, corporate, and smaller markets. The 30 attendees participated in a discussion following the presentation. — Gerald A. Finn (Faculty Advisor), Pasadena City College.

Pasadena City College Student Chapter, March 27, 1990 — Jim Johnston, first assistant property master for Carsey-Werner, discussed a typical work week in the life of the television series "Grand." A former Pasadena City College student, Johnston defined the roles of a set master, a property master, and the property department. He also explained how a script is blocked, using a marked script from "Grand" as an example. He shared several tricks that are used to effectively dress a set, such as marking the furniture to insure continuity. During his presentation, Johnston stressed the importance of good work ethics in a job performance. The meeting was held at the Pasadena City College and was attended by 27 people. — Gerald Finn (Faculty Advisor), Pasadena City College.

Attendees listen to a presentation on broadcasting during emergency earthquake situations at the San Francisco Section's March meeting.

San Francisco, March 22, 1990 — An account of how engineering staffs and broadcasters coped with last year's earthquake in San Francisco was the topic of a symposium entitled "Bay Area Broadcasters vs. the Great Earthquake of 1989." Since television cameras were preparing to broadcast the World Series baseball game between Oakland and San Francisco when the quake occurred, this was perhaps the first earthquake to be broadcast "live" over national television. Initially, many television and radio stations lost power as a result of the earthquake, then one by one, during the following minutes and hours, they reappeared on the air. Seven of the area's principal engineers discussed how they performed under these extremely difficult conditions.

Steve Moreen, KPIX-TV, said that it was a stressful situation that took its toll on employees. "Teamwork was needed and the technical staff responded like champs," he said. Because their video monitor is fed by Viacom cablevision, which went down, the staff thought they were off the air even though they were not. The station now has a monitor connected to an antenna on the roof which, despite the poor reception in the area, provides assurance that they are on the air. During the ten hours following the earthquake, KPIX-TV operated on emergency power provided by two 155-W generators. "The station also had a 110-kW generator at the Sutro transmitting tower and a 100-kW generator at the El Cerrito earth satellite station," he said. "The satellite station provided a major uplink out of town for the next five days and also served KGO-TV."

Lou Bell, KNTV, San Jose, reported that the station suffered extensive damages at a cost of half a million dollars or more. At the Loma Prieta site the TV antenna and tower were damaged and are currently being replaced. Bell said that all equipment that was not tied down fell onto the floor. "Diesel fuel tanks fell off their stands, contaminating the soil, and required expensive removal. The new fuel tanks are mounted on hardened concrete bases and are double-walled. Double-containment piping carries the fuel to the generator," he said. "Mistakes were made in earthquake preparation, so now new planning is in process. Management needs to support preparation with funds. Disaster planning is one of our greatest challenges."

Dave Phillips, KGO-TV, said the station had three 225-W generators on the roof of the building and a 10,000-gallon fuel tank on the side of the building, which provided good emergency power; however, the phone lines were out. "Fortunately, we have digitally sequenced, addressable control from all of our mountain tops," he said. "Each mountain top is individually controlled and puts the control out over the pro channel so we can get away from dependence on their phone lines." The station also sent camera crews out on ENG trucks so that equipment was available on both sides of the bay and positioned to feed news back to the station. This is a costly system, but proved to have merit. Although KGO-TV lost its wire phone, it was able to contact a sister station in Houston and establish wire communication. Phillips pointed out that there was no air conditioning or air movement and windows could not be opened. "Both people and equipment suffered as temperatures in the newsroom rose to 95°. Air conditioning needs to be considered for emergency power requirements," he said. "The station operated for 3½ days on emergency power. The care of people is also very important. They need to be fed as well as housed. Cots, food, and water need to be on hand."

The new student chapter at Napa Valley College recently held its first meeting. Seated from left are Jon M. Gulfo, Ann Grant, Vernon L. Kipping, and Gary Vann. Standing are Ken W. Graham (left) and Charles Hintz.

Roy Trumbull, KRON-TV, said the station overrelied on existing commercial power grids, which became unavailable from Tuesday evening to Friday evening — one small generator powered some of the racks. An ENG truck provided power, and cables were run to a master control where a camera was set up with a microphone and lights. The station was able to operate for four hours using one transmitter. A makeshift studio was set up in the parking lot, and a dumpster served as a shelf to hold equipment. One problem was a lack of outlets to plug a cannon connector into the equipment on the transmitter site. A cable was made up by soldering and this problem was surmounted. A pictorial map of the Bay Area served as a graphic tool to show sites of new action. Because of power generation limitations, only vital equipment was operated. For the future, KRON plans to install a new generator. Although this is a costly investment, Trumbull said that emergency contingencies need to be considered and alternate transmitter sites are being studied.

Bill Ruck, KNBR (the primary Emergency Broadcasting System for San Francisco) and KFOG-FM, stressed the importance of simplifying emergency plans. A problem he experienced was that he was shortstaffed since many of the station's personnel were at Candlestick Park covering the World Series. "The biggest problem we had was that the switchboard operator failed to realize that to get back on the air after the power failure, he needed to simply hit a button on the console because the emergency power generator came on when the commercial power failed. It was further discovered that it was possible to simulcast both KNBR and KFOG-FM from the transmitter site, which was very useful." During the emergency, EBS was used by Alameda County and San Francisco to summon all fire and police personnel to report for duty. San Francisco Mayor Agonos also wanted to make announcements on EBS and a Motorola transmitter was used. However, this equipment is intended only for intermittent use and therefore has to be keyed every 90 seconds. Another major problem was that stations were uninformed on such events as road closings. The public officials' staffs failed to supply that information. In addition, Ruck recommended that a structural engineer be consulted for appropriate seismic bracing of equipment, stairways should be well lit, and a water booster be available for drinking and plumbing needs.

Ken Manley, KTVU-TV, said that there was a power failure at the transmitter sight and an ENG truck was used in a successful first attempt at returning to the air, in spite of audio problems that were experienced. Power loss was attributed to a failed switch on the generator in the basement, and it took two hours to bypass the switch because the generator was not interlocked properly. In addition, the diesel overheated due to a head gasket failure. He recommended that equipment be checked every day to avoid problems during an emergency.

Stu Casteel, Hewlett-Packard, presented a videotape documenting the extensive damage sustained by his facility. The damage was so great, the company had to abandon the building and move operations. He noted that equipment on shelves or in racks fell to the floor, but equipment on wheels just rolled around and sustained no damage.

The meeting was held at the studio of KPIX-TV and was attended by 90 people. In addition, an estimated audience of 200 to 300 people watched via satellite. Viewers reported in from outside locations such as New York, Florida, Michigan, Nebraska, and Western Canada. Section Chairman Peter Hammar closed the program with a question-and-answer session.

During the meeting, the formation of the new student chapter at Napa Valley College was announced, and Gary Vann, the faculty advisor, was introduced. SMPTE Governor John A. Carlson presented a plaque to Vann and to student chapter officers, Chairman Jon M. Gulfo and Secretary/Treasurer Ken W. Graham, commemorating the designation as a student chapter of the SMPTE. — Vernon L. Kipping (Secretary/Treasurer), consultant.

Section Chairman Peter Hammar moderates a question-and-answer session at the San Francisco Section's March meeting.

News

William H. Smith was honored at the Vision Fund of America's 1990 Awards Banquet on May 1, 1990, for the many contributions he and his company, Allied Film and Video, have made to the motion-picture industry, particularly in the area of printing and processing techniques. He is president and chief executive officer of Allied, which he founded in 1960.

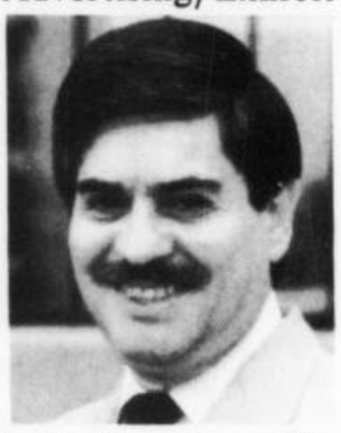
An SMPTE Fellow since 1972, Smith has been active in several industry organizations. He served three terms as president of the Association of Cinema and Video Laboratories, was a member of the international organization serving professional film and video laboratories throughout the world, held a seat on the board of directors of the Detroit Producers Association, and was on the SMPTE Board of Governors. In addition, he chaired the SMPTE Committee on Educational, Industrial and Consumer Technology. In 1985, he received the SMPTE Presidential Proclamation in recognition of his work in the audiovisual industry, and in 1988, he was named a Fellow of the British Kinematographic, Sound and Television Society.

The Vision Fund of America is an association of video industry professionals dedicated to helping people with partial sight. The award was presented by Karl Malden, honorary chairman of the banquet and president of the Academy of Motion Picture Arts and Sciences.

Arriflex Corp. was presented with an Award of Outstanding Achievement in Engineering Development for its 765 and 535 motion-picture camera systems, by the International Photographers Guild (IPG). Upon presenting the award, Local 659 President George Spiro Dibie said, "Both cameras bring new technologies and especially new creative possibilities to the working camera system." The award was accepted by Arriflex Western Sales Manager Bill Russell at a ceremony held during a regular IPG meeting in Hollywood. The Local is the representative of over 3000 directors of photography, operators, camera assistants, and crew members within its 13 western state district.

A student scholarship has been made available by Optical Radiation Corp. (ORC) through SPIE, the society for optical engineering. The applicant must be enrolled in a qualified institution and involved in any study or use of light from the near ultraviolet to far infrared. Such study or use must take advantage of non-natural light or illumination requiring an electrical discharge, excluding a laser source. This activity should be centered around the propagation, generation, and manipulation of light or the interaction of such light with matter. Subject application of light should also be germane to any scientific, industrial commercial, and/or military device or system. ORC has agreed to a five-year commitment in the annual amount of $1500. The first award will be presented in July at the SPIE Show in San Diego. For more information, contact Scott Walker, SPIE, P.O. Box 10, Bellingham, WA 98227.

Alan Ehrlich has joined the SMPTE headquarters staff as Advertising/Exhibit Manager. His responsibilities include supervising the equipment exhibits and coordinating their promotion as well as working as liaison between exhibitors and on-site service contractors. He will also be responsible for *Journal* advertising. He was previously with Thalheim Exposition Co. in Manhasset, N.Y., where he supervised the sales, marketing, operations, advertising, and floor management of a variety of trade shows held at the New York Coliseum and, subsequently, the Jacob K. Javits Convention Center. The shows he managed include the Premium Incentive Show, the Back-to-School Merchandise Show, and the American International Fur Fair. During his seven years at Thalheim, Ehrlich was also responsible for the sale of over 1000 new spaces to exhibitors such as Borden's, Binney-Smith, Aladdin, Inc., and Krazy Glue.



A resident of Great Neck, N.Y., Ehrlich likes to spend his spare time working on his hobby, photography. He is an experienced darkroom technician and a past-president of the Long Island Color Print Club. His second love is cooking and he is skilled in preparing gourmet dishes of various cultures, including Chinese, Jewish, West Indian, and Italian. He is the father of two daughters, Jeannine, 15, and Randi, 12.

Ajay Chopra, cofounder and vice-president of engineering, Pinnacle Systems, has been elected chairman of the board by the company's board of directors. He had previously served as founding president. Prior to starting up Pinnacle in 1986, Chopra worked at Mindset, a computer graphics firm, where he was responsible for developing the company's professional video business. He also has prior experience with Burroughs Corp. and Atari.

Joe P. Wellman has joined Microtime Inc. as marketing manager. He previously served as sales manager, eastern region, for the CMX division of Chyron Corp. He has held various positions during his career, including operating his own business, Video Television Representatives, where he provided sales and engineering services to companies such as Hotronics and JVC. He also worked as a field engineer and a test and bench technician for Westinghouse, Philco Ford, Microtel, and Panasonic.

Richard A. Cooper has been named national sales manager, robotics, for A.F. Associates. He formerly worked for Total Spectrum, Inc., as broadcast sales manager. Before that, he served as vice-president of operations for Vinten Equipment, Inc., where his primary responsibility was for sales of robotic camera control systems.

A courtesy reference center has been established at Alan Gordon Enterprises within its technical book department. The center, which consists of a collection of location guides and production directories provided by state and regional film commissioners from across the U.S., is designed to be used by producers, production managers, and industry professionals. The materials are available for on-site browsing and production planning. For more information, contact Fred Ginsburg or Mike Kelly, Book Publications Division, Alan Gordon Enterprises, 1430 Cahuenga Blvd., Hollywood, CA 90028.

A series of application notes has been made available at no charge to industry professionals by Videotek, Inc. According to the company's marketing manager, Eric Walbergh, this service was designed to alleviate the difficulties that many users were having in understanding the elements that compose a video system. Each issue is written by Mark Everett, who has over 20 years of experience in system design, sales, and installation. Covered by the series are topics such as a glossary of technical terms, vertical and horizontal sync signals, system timing, how to use a waveform monitor, and timing relationships. For more information, contact Eric Wahlberg, Videotek, Inc., 243 Shoemaker Rd., Pottstown, PA 19464.

Obituaries

Daniel R. Brewer

Daniel R. Brewer

Daniel R. Brewer, director of engineering and technical services, Paramount Pictures Video Operations, died of a heart attack in February 1990, at the age of 64. An SMPTE member since 1969, he had been active in several engineering committees, including the Working Group on High Definition Electronic Production and the Television Technology Committee. Last October, Brewer served as Television Topic Chairman for the 131st SMPTE Technical Conference and Equipment Exhibit held in Los Angeles. During that time he also played a key role in coordinating a live, all-digital HDTV broadcast sent by satellite between Tokyo and the Los Angeles Convention Center.

Prior to joining Paramount in 1983, Brewer held positions at CFI, Universal Studios, and the Burbank Studios. He also served in engineering capacities at the University of Southern California, RCA, and NBC. At RCA, he was active in the group that worked with the NTSC on color television development. In 1982, he received a technical achievement award from the Academy of Motion Picture Arts and Sciences. He was a governor of the National Academy of Arts and Sciences and a past-president of the Society of Television Engineers. He was a member of several other engineering societies, including IEEE and the American Society of Lighting Directors.

Born in Omaha, Neb., Brewer conducted his undergraduate work at the University of Southern California, and received his B.S.E.E. from West Coast University in Los Angeles. He is survived by his wife, one son, and two daughters.

Ted H. Horn

Ted H. Horn, owner of Keras Film, died on February 28, 1990, at the age of 67. He had been an active member of the SMPTE since 1965 and a lifetime member since 1987. Born and raised in Germany, Horn migrated to the U.S. in 1951 and became a citizen in 1956. In his first job as a citizen he worked as a cameraman for News Reel Laboratories in Philadelphia. In 1957, following Eastman Kodak Co.'s introduction of the Kodachrome process, Horn joined Albern Color Research where he operated the Kodachrome department and served as quality control manager of other photo finishing processes. During that period, he authored "Artificial Aging of Latent Image in Ektacolor Paper," which was published in the *SMPTE Journal*. In 1961, he joined Dek Processes, where he outfitted and operated the Fort Wayne, Ind., plant. He also set up a quality control system, designed an automatic film feed device for continuous license-form printing, and developed and patented an opto-electronic alphanumeric data feeder for the EDP of motor vehicle departments.

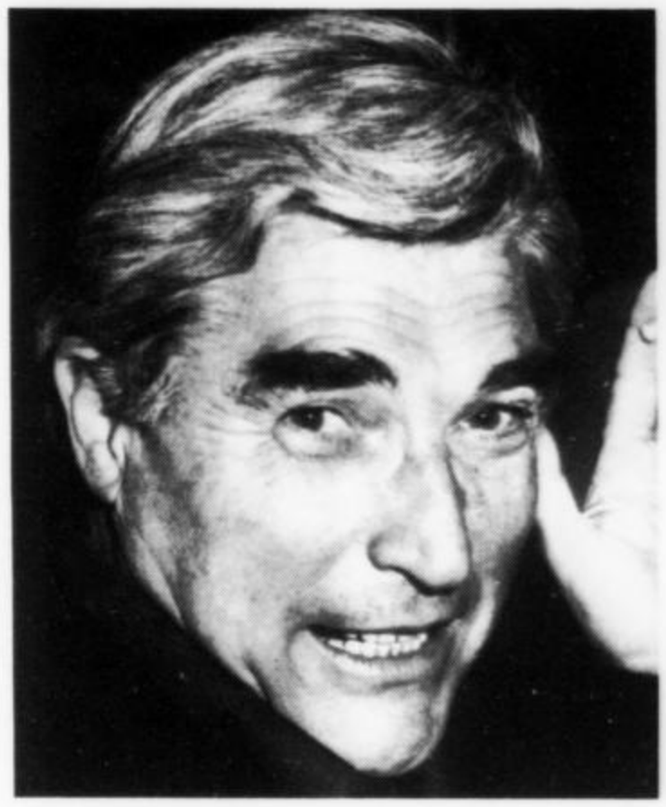
Ted H. Horn

In 1964, Horn joined General Film Laboratories as a plant manager, where he worked with a local NBC affiliate and the University of Michigan on establishing black-and-white Kinescope parameters for repeatable results. In 1969, he went to work for Chrysler Corp., building and operating a 16mm color lab for processing and printing instrumentation footage. He later became involved in Chrysler's instrumentation photography and in-house motion-picture film productions.

In 1976, Horn received the second place award in the Industrial Film Competition. In 1984, he received the SMPTE's Citation for Outstanding Achievement to the Society. He is survived by his wife Herta, two daughters, and four grandchildren.

Claude Soulé

Claude Soulé, director general of the Commission Superieure Technique du Cinema Francais, is dead at the age of 62. An Active Member of the Society, he was best known for his role as permanent general secretary of the Union Internationale des Associations Techniques Cinematographiques (UNIATEC), of which the SMPTE is a member.



Claude Soulé

During his lifetime, Soulé authored many internationally published technical papers. He also gave numerous conference presentations throughout his career. He was active in the industry for over 40 years and was deeply involved in the development and application of technical standards within the French film and television industry. He was also a strong proponent of standards in the area of motion-picture exhibition. His professional affiliations included membership in ISO, UNESCO, Comission des Archives du Film, and Groupement des Acousticiens de Langue Francaise.

Soulé held various patents in the field of cinematography and television, and was rewarded for his contributions by many national and international awards of merit, including the Chevalier de l'Ordre National du Mérite and the Chevalier des Arts and Lettres.

James M. Frazee died on December 23, 1989, following a long illness. A long-time employee of the Department of the Navy, Office of Naval Research, he retired in 1978. He had been an Active Member of SMPTE since 1954 and became a Life Member in 1979.

A. Kraszna-Krausz died on December 24, 1989. A consultant, he had formerly served as the chairman and editor-in-chief of Focal Press Ltd. prior to his retirement in 1978. He joined the SMPTE in 1929 and he was elevated to Life Member status in 1980.

Robert S. Mautner, a Life Member of the SMPTE, is dead. He joined the Society in 1947 and during his career held positions at Warner-Quinlan Co.; RCA; and Varian Associates, Solid State Div.

Robert V. Rose died in May 1989, at the age of 68. Born and raised in Denmark, Rose joined the Society in 1957 while he was employed by Manners Engineering Ltd. He later worked in Hong Kong for Gilman & Co. Ltd., Queensway Co., and U. Spalinger & Co., Ltd. While in China, he started his own company, from which he retired in 1985. He had been a Life Member since 1986.

Thomas K. Tennant died on February 12, 1989, at the age of 69. A Life Member since 1986, he joined the Society in 1949 as an Associate Member, upgrading to Active Membership in 1959. During his lifetime, Tennant's employment included proprietary positions at Civic Theatre Euroa and Victory Theatre Tatura. He also served in the Australian Air Force as a senior projectionist.

Lucien P. Tuckerman, a Life Member of the SMPTE, is dead. He joined the Society in 1936 as an Associate Member, transferring to Active Membership in 1950 and Life Membership in 1970. During his lifetime Tuckerman held positions at Bell Telephone Laboratories, Harry Diamond Laboratories, and the National Bureau of Standards.

Andre G. de Tonnancour, owner of Les Films de Tonnancour, died on March 2, 1990, at the age of 67. His professional achievements include the design and construction of a lightweight, computer-controlled 35mm animation camera based on a Nikon F-3 body and a Universal, single-frame or variable speed motor for a Mitchell 16mm camera. He had been an Active Member of the Society since 1988.

Terry F. "Buck" Evans, KHJ-TV, died at the age of 52. He was serving as the director of engineering for the station at the time of his death. He had previously been employed by Broadcast Communications Devices, Donrey Media Group's Broadcast Div., KCST-TV, and KLBK-TV. Evans had been an Active Member of the Society since 1978.

Henry S. Greenspan, Capital Cities/ABC, died at the age of 63. An ABC employee for over 20 years, he had previously worked for Visual Electronics Labs and Educational Electronics of California. He graduated from Oklahoma University in 1945 and later attended Pierce College. He had been Active Member of the SMPTE since 1979.

William J. Hagen, 65, died on January 2, 1990. An employee at Encyclopedia Brittanica for 23 years, he was a leader in educational film production. He had been an Active Member of the Society since 1969.

Percy M. Hollingsworth died at the age of 63. Prior to his position as CEO of Technical Opportunities Inc., he served as president and general manager of Startronic Electrons Corp. He was an Active Member of SMPTE since 1966.

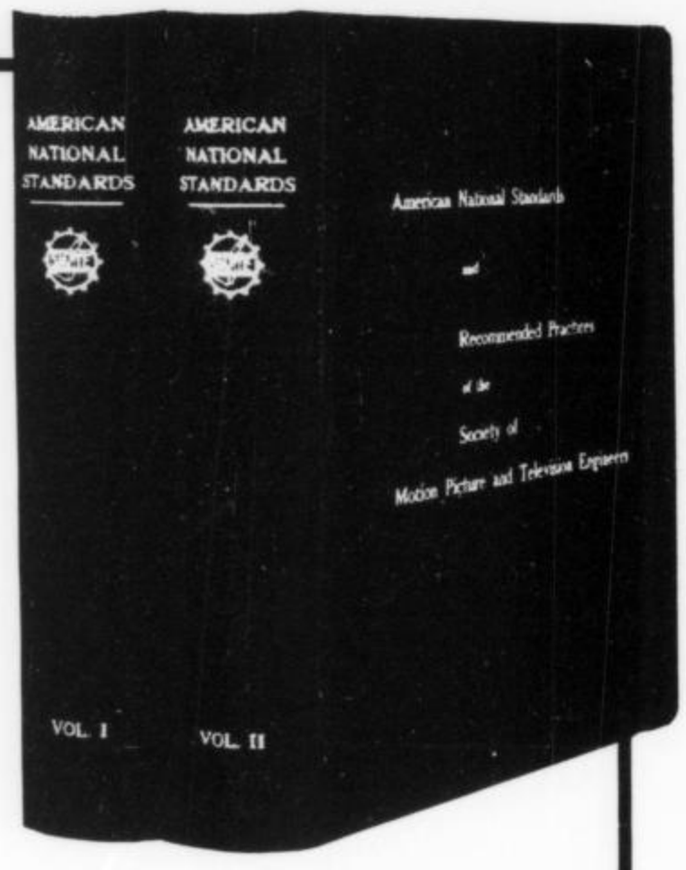
George E. Hughes, an employee of Aerospace Audiovisual Service for over 20 years, died at the age of 69. He had previously held positions at American Forces Radio and Television and European GEEIA. He was an Active Member of the SMPTE since 1979.

Ryosuke Nishimura, Maruzen Co., Konica Div., died recently. During his lifetime he had been president of the Society of Scientific Photography of Japan and the technical director of the Konishiroku Photo Industry Co. An Active Member for 36 years, Nishimura joined the SMPTE in 1953.

John F. G. Ryan, Australian Broadcasting Corp., died at the age of 53. An SMPTE Associate Member since 1968, he was upgraded to Active Member status in 1987. He graduated from the Collingwood Technical School and Royal Melbourne Technical School, and had over 25 years experience in film sound recording.

Allan W. Hawkins died at the age of 92. He had been an Associate Member of the SMPTE since 1968. He was retired from the Public Service Gas & Electric Co. of South Orange, N.J., where he had produced company films as a sideline. He also spent over 30 years in the construction of 16mm sound recorders and cameras.

Binders for SMPTE-sponsored American National Standards and SMPTE Recommended Practices



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595 West Hartsdale Ave., White Plains, N.Y. 10607

Errata

March 1990 Journal

Re: "Control and Prediction of Film Density and Color Balance in the Developing Process," by Lars-Erik Kjellström

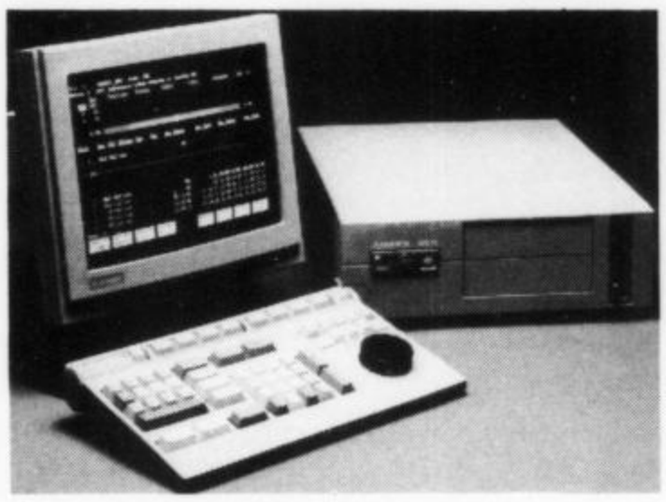
Page 193, first column, tenth row from bottom: "$d \times a$" should read "$d \times x^2$" (a coefficient times x squared).

Page 197, third column, seventh row from bottom: "Fast computers also disrupt the old attitude and avoid problems . . ." The author would like to change this to read "Fast computers also disrupt the old attitude of avoiding . . ."

New Products

Further information about these items can be obtained from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturer's statements, and publication of these items does not constitute endorsement of the products or services.

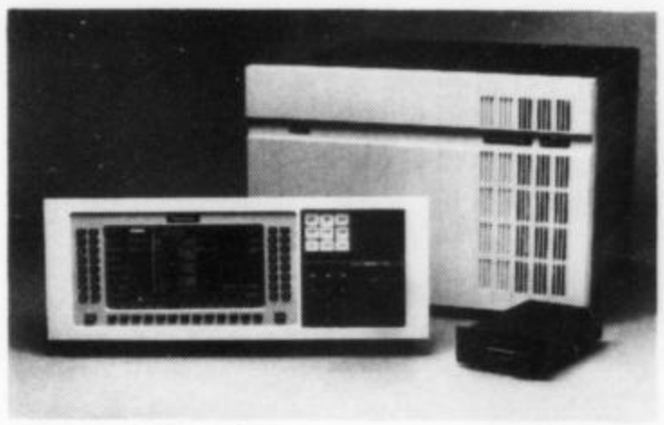
Several new products have been unveiled by Ampex Corp., 401 Broadway, Redwood City, CA 94063-3199. The **VPR-200** (three cassette capability) and the **VPR-250** (two cassette capability) D-2 studio VTRs are optimized for broadcast applications where fast, easy operation, signal quality, cassette play length, and maintainability are key. The VPR-200 supports all three D-2 cassette sizes with play times up to 208 min. The VPR-250 supports the small and medium cassettes with play times up to 94 min. The **VPR-350** (two cassette capability) D-2 studio VTR is a high-performance machine optimized for post-production applications where signal quality, multigeneration performance, and high-speed editing capabilities are desired. It supports all three D-2 cassette sizes with play times up to 94 min.



Ampex Ace 10 video editing system

The **Ace-10** video editing system operates on a standard computer platform. It features a simplified operations keyboard, help text, easy-to-read status display, and list management capabilities. The system is designed to provide practical features essential in newsroom or corporate editing environments, such as a switcher control, sequential auto-assembly, and a 250-event decision list. List output may be in either SMPTE or CMX 340 format.

New 4:2:2 component digital and component analog input/output capabilities for the ADO® 100 digital effects system makes high-quality component digital effects affordable for broadcasters and post-production facilities in a variety of applications. The **CCIR-601 component digital ADO 100 system** is ideally matched for component analog suites based on Betacam format VTRs where it is desirable to maintain the component analog signal path throughout the production process.



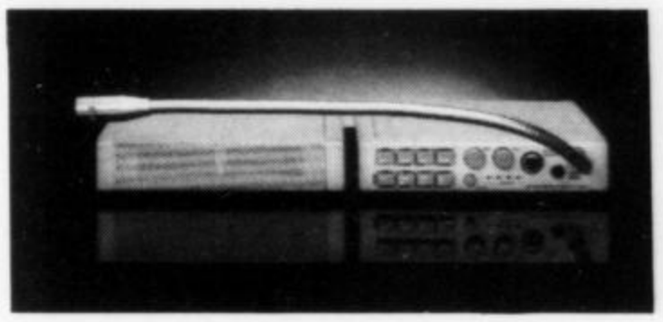
Ampex CCIR-601 component digital ADO 100 system

AutoResolve, a software designed for the company's ACR-225 digital automated cassette system, allows the video cart system to automatically identify and resolve future playlist conflicts that would prevent the system from executing its on-air playlist. In advance of scheduled air time, the product compares the selected playlist with the contents of its on-line library. During this process, the system will identify any spots which cannot be played as specified by the playlist.To resolve conflicts, the system will precue events and, when necessary, create a buffer copy or break tape automatically. Specific cassettes are designated by the operator for use with conflict resolution. Buffer copies and break tapes can be created during system idle time.

The **CVR-400** has been added to the company's family of Betacam SP camcorders. It features an advanced high-resolution frame interline transfer CCD sensor, which virtually eliminates vertical smear. An optional interface capability allows the product to feed component signals simultaneously not only to its own VTR but to another VTR as well. The stop/start function and viewfinder playback of both VTRs can be controlled from the system.

Vidlites, a line of custom designed Videssence studio and ENG/EFP lighting products, come in two compact packages that cover the range of field applications. The products are based on the sustained plasmatic ionic light concept where the lights resemble compact fluorescent fixtures but emit a very bright, flickerless, tungsten-balanced light. The light fixtures are mounted in lightweight, rugged field cases that are actually part of the mounting system. Configurations may be changed in a matter of seconds, giving the field crew flexibility that is not achievable with conventional lighting systems.

FA-700, an operationally independent time base corrector that provides full frame S-VHS and ¾-in. U-matic time base correctors, has been announced by For-A Corp. of America, 320 Nevada St., Newton, MA 02160. Each time base corrector provides separate Y/C358 and composite video inputs as well as Y/C358, Y/R-Y/B-Y and composite outputs, requiring only a single input genlock reference. In addition to Y/C358, the product provides clean processing and optimum picture resolution with ½-in. and ¾-in. VTRs due to its wideband CCD comb filter, making it fully compatible with SP ¾-in. U-matic formats in particular. It also features full color frame memory, automatic picture freeze, and black stretch plus digital dropout compensation.



RTS Systems MCE325 programmable user station

Two new products have been introduced by RTS Systems, 1100 W. Chestnut St., Burbank, CA 91506. **Model MCE325 user station** is a four-channel, user programmable intercom station that features a modular packaging technique. It can be utilized in any one of five package arrangements: rack mount or portable headset station, rack mount or portable speaker station with a modular speaker, and console headset station. With its software and hardware base programming, the station can be operationally and functionally configured in a variety of arrangements to suit individual requirements. It is designed to work as a TX intercom system user station. It can be used in conference-line or talk/listen or four-channel combo talk/listen in two-wire or four-wire line mode. Additional features include a centrally generated remote talk-off signal to turn off all microphones, call signaling, and two-program inputs.

The **Series 2200 Wireless Cue System** is a one-way communication system that features full bandwidth from a single transmitter to multiple receivers. Typical applications include interrupted and non-interrupted program feeds to on-air television and radio commentators, intercom monitoring for behind-the-scene personnel, and sound enhancement for hearing-impaired people. It operates in the VHF frequency range between 72 and 76 MHz and offers a selection of eight frequencies.

A line of lighting and grip products and an advanced camera have been announced by Arriflex Corp., 500 Route 303, Blauvelt, NY 10913. **Model 535** 35mm motion-picture camera system features virtually every mechanical and electronic accessory now in common use, in addition to several unique offerings. Its features include a microprocessor control technol-

ogy that oversees the entire range of camera functions, a swingover viewfinder that pivots 270° left to right and 360° parallel to the lens axis, and a programmable Arriglow, which provides eight different illuminated formats, with any three displayed in the finder simultaneously. It also has dual LCD information displays; built-in SMPTE Time Code/Kodak Keycode generator/reader; multilink, nonlubricated movement; a universal aperature plate with interchangeable metal format masks; and a new 24-V DC power system.

Grip products designed to solve a wide variety of recurring problems, include the **Arri Magic Arm,** which is a three-point articulated arm that locks with a single lever in any position to hold small objects in space, the **Double Telescope Hanger** which is used to hang television lighting fixtures from studio grids, the **Sparrow Plate** which is a miniature version of the traditional 3-in. wall plate, the **Mini Flextion™** which is a 6-in. long flexible arm designed to be mounted in the Arri grip head or other clamps and is used for very fine adjustment of dots and fingers, and the **Maxi Flextion,** which is also 6-in. long, but designed to hold much heavier media such as 12×18 flags and nets.

The 1000/3 Fresnel Kit, which has three 1000-W compact fresnels and a full complement of stands and accessories and the **2000/2** consisting of two cool-touch, Arrilite 2000 open face lights with barndoors, scrims, stands, and lamps, are two new heavy duty portable lighting kits.

The pole-operated **1-kW, 2-kW, and 5-kW Studio Fresnels** have been added to the company's lighting line. They outperform traditional lights by 40% and are easier to handle and work with, reducing crew time during rehanging and refocusing. Features include cool operating temperatures.

Electronic ballasts, built to survive modern on-location video and film productions, are available in 2,500-W and 12,000-W fixtures. They eliminate the concern for density changes or flicker when shooting up to 10,000 frames/sec. Light output is increased by approximately 5% with both constant light output and constant color temperature over the entire life of the lamp. As an added advantage, the ballasts permit fluctuations of up to 10% in both voltage and power supply frequency with a nominal effect on lamp power and no effect on the ballast's flickerfree capability.

Creation of up to five layers of video in a two channel system is now possible via the **DCC-21 Dual Channel Combiner** available from Pinnacle Systems, Inc., 2380 Walsh Ave., Santa Clara, CA 95051. The

Pinnacle Systems DCC-21 dual channel combiner

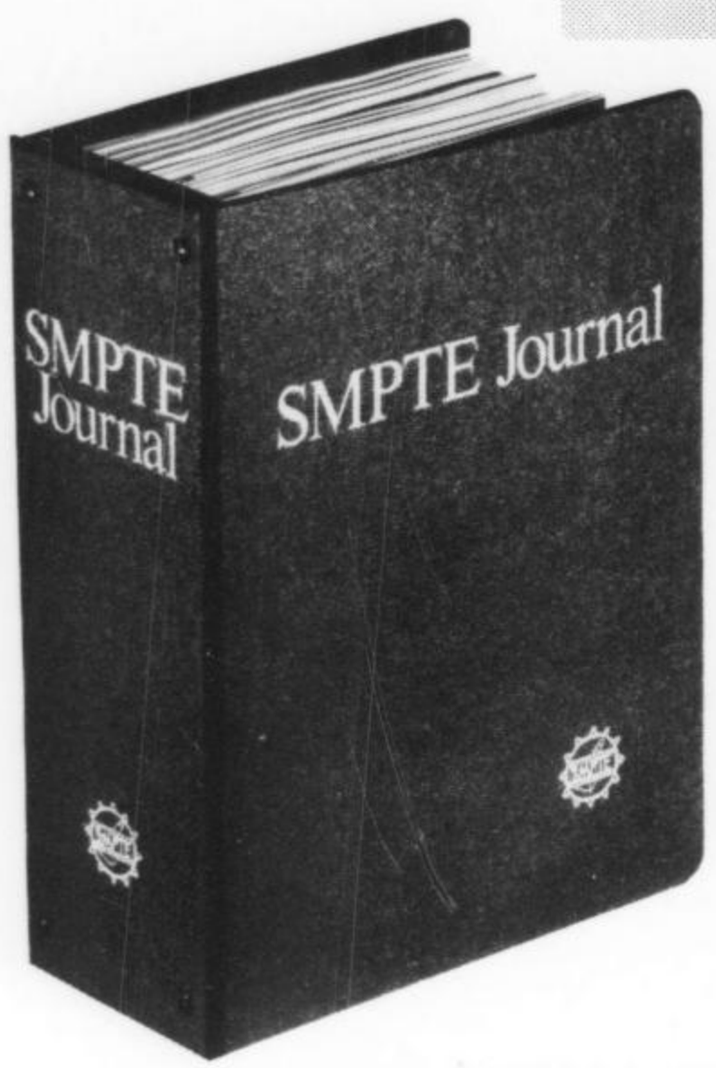
product is designed for use with the 2100 Series Video Workstation™ and allows users to simultaneously manipulate images with input from two separate workstations using a single control panel. Multiple layering is achieved through two live images and two still montages keyed over a background source, which reduces the number of passes needed to complete a project. The product can optimize machine utilization because operators can work in either a dual or single channel mode. In addition, the user can set the priority in which the video from the two workstations will be displayed at the DCC-21 video output.

A family of products has been introduced by Dynair Electronics, 5275 Market St., San Diego, CA 92114. The **LED/PIN fiber optic line of self-contained video transmitters,** is available in three distance/bandwidth options to serve broadcast, education, corporate, and CCTV applications as well as the needs of command and control systems where computer graphics are frequently used.

Dyna Mite routing switcher, now available with full alphanumeric source and destination displays, has also been announced. The mnemonic display titles show actual names versus numbers only, so that the operator can make mistake-free selections and easily monitor the current status of the system. It has a 40-MHz capability and is the first system of its size that provides video, audio, and control within one frame. It is designed to handle NTSC, PAL, and SECAM, as well as all proposed ATV and HDTV signals and medium resolution graphics signals.

The **D2 digital switching and distribution system** for broadcast facilities incorporates an approach used for many years in the telecommunication industry to overcome bandwidth, system timing, and cabling considerations. Bipolar AMI-B3ZS coding is used for bringing digital switching and distribution to television facilities. This type of coding results in no system tilt, few cascaded genlocks and clamps for quick transient recovery, easy setup and maintenance, and fast troubleshooting.

Series 3100 — a line of six output 30-MHz utility video, equalizing video, and pulse distribution amplifiers — is avail-



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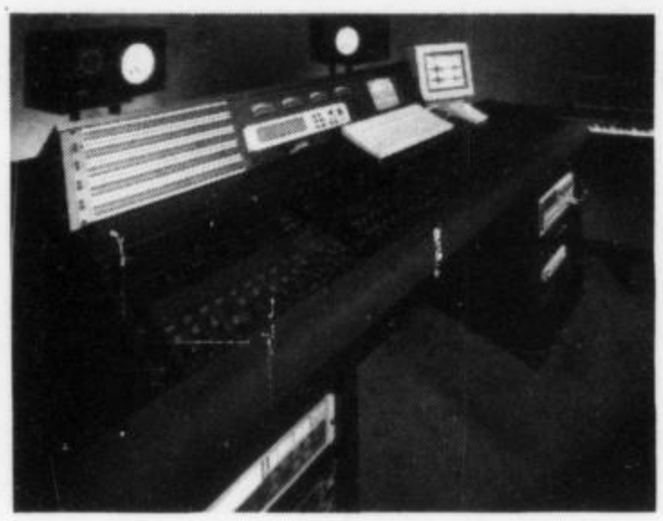
able in a modular design that can be organized into one or two unit packages. The products are designed to meet the requirements of corporate video, including training, videoconferencing and security, and entertainment and broadcasting facilities, such as duplication, production, post-production, and any studio application. The video equalizing modules can compensate for up to 1000 ft of Belden 8281 or equivalent coax cable.

Postpro™ SD, an integrated workstation that combines Synclavier® sound design capabilities with Direct-to-Disk™ recording and editing in one enclosure, is available from New England Digital, 49 S. Main St., White River Junction, VT 05001. Offering 8 separate Synclavier outputs and up to 16 tracks of disk recording, the product presents a full array of sound design capabilities and disk recording and editing functions. It is available in 8 or 16-track configurations and offers nearly 30 min/track of continuous recording time at 44.1 kHz. The sound design module is completely integrated into the overall system and is compatible with an Apple Macintosh® interface. The product is available with direct digital I/Os for AES/EBU, ProDigi, and SDIF-2 formats; VITC and SMPTE synchronization; multirate sampling from 1 to 100 kHz, user variable; as well as comprehensive training and service.



Video Post and Transfer dream™ system

An all-digital multifunction audio system designed for television post-production has been unveiled by Video Post and Transfer, Inc., 8036 Aviation Place, Box 53, Love Field Terminal, Dallas, TX 75235. The Digital Real-time Editing and Audio Master system (dream™) is the first system of its kind for the on-line edit suite. It incorporates a 16×4 fully-automated digital mixing console complete with on-board digital effect, digital outboard processing equipment, compact disc playback in the digital domain, A/D and D/A processing for use with analog sources or destinations, digital Foley and sound effects capability, and a digital audio workstation for music editing and dialog replacement. In addition, the system includes a musical instrument digital interface (MIDI) keyboard for real-time entry of sound effects and music stingers,

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From the moment you experience the cutting edge quality of the HK-355, you'll realize that this is no ordinary chip camera. From its lightweight aluminum design to its outstanding specs, Ikegami's premier Studio Field chip camera is simply the best ever built.

The HK-355 features three FIT 2/3" Chips each delivering 450,000 individual pixels, a resolution of 800 TVL and a S/N ratio of 62dB. A newly developed optical LPF (low-pass filter) insures exceptional response characteristics, while our CCD driving system and 3-DTL enhancer results in dramatic improvements in vertical resolution, and substantial reductions in moire noise patterns. The HK--355 also features Ikegami's exclusive Automatic Colorimetry Correction Circuitry.

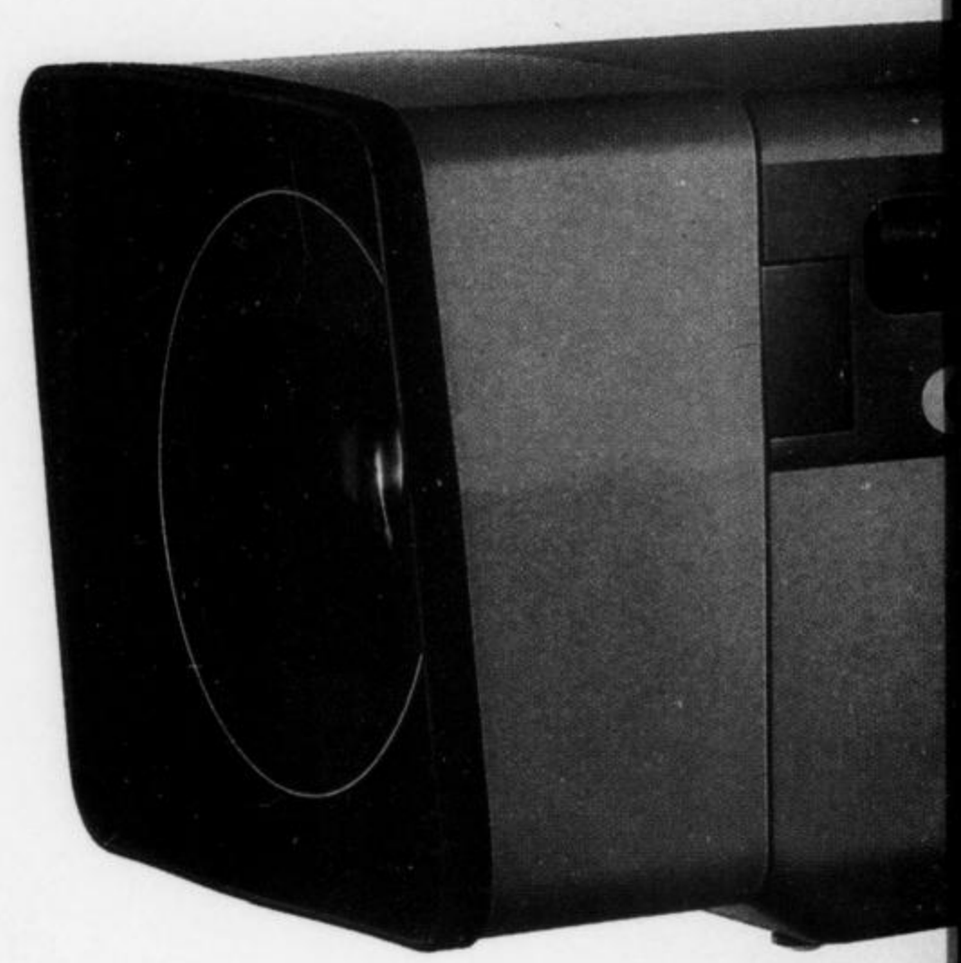
Breakthrough engineering that incorporates auto level setup functions with chip technology, eliminates various setup functions associated with tube cameras, while triax, multicore, and fiber optics are connected via simple plug-in modules.

Additional features include plug-in board design for easy maintenance, a computer controlled CCU, a 7" viewfinder and optional 7" color viewfinder.

A hand-held version, the HK-355P, is available and can operate from the same base station or with any popular recorder.

Owners of Ikegami's outstanding HK-323 tube camera can enjoy total compatibility with all HK-355 accessories, allowing them to own the finest studio chip camera at a substantial costs savings when compared to the competition.

For information on the studio chip that's best, contact your Regional Sales Office or the Ikegami dealer nearest you.



IKEGAMI'S HK-355P PORTABLE COMPANION CCD

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as well as compatibility with external MIDI files and equipment. The system operates at 48 kHz and accepts AES/EBU signals in-and-out with an internal resolution of 24 bits.

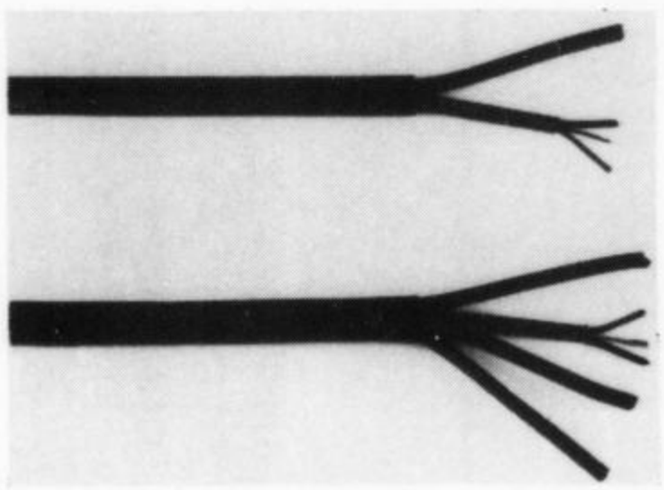
Alan Gordon Enterprises 12-120 Mini Invertor

Two new audio power supply products have been launched by Alan Gordon Enterprises, 1430 Cahuenga Blvd., Hollywood, CA 90078. **The Lavalier Power Supply** is designed for use with Sennheiser MKE-2 or TRAM TR-50 Lavaliers. Equipped with Vega compatible Lemo connector, the unit provides excellent gain for clean audio production. A metal casing protects all sensitive parts from damage and shields against RFI and other electro-magnetic interference. **The 12-120 Mini Invertor** is a simple means of powering AC mixing panels and other equipment from 12-V batteries. The unit converts 11 to 15-V DC to clean 115-V AC ±5% and provides continuous power up to 100 W. The peak output is 200 W with a 90% efficiency. Other features include low battery alarm-audible warning at 10.7-V input and low battery shutdown at 10.0 V.

A double-coated pancake videotape has been announced by Fuji Photo Film, Magnetic Products Div., 555 Taxter Rd., Elmsford, NY 10523. UH400 is constructed of two separate layers of magnetic particles instead of a single layer, so that audio and video signals are finely tuned to produce quality results. From the bottom, the product features a 14.7-μ thick base film layer under a 0.3-μ thick undercoating layer. The third layer is 3.5-μ thick and consists of Beridox DC-A particles which are specially formulated to optimize the output of the longer wavelength, low-frequency audio signal which reaches farther into the tape structure than the shorter wavelength video signals. The top layer is 0.5-μ thick and is constructed of new superfine cobalt modified ferric oxide Beridox DC-V particles that are designed to optimize the recording of the higher frequency video signals.

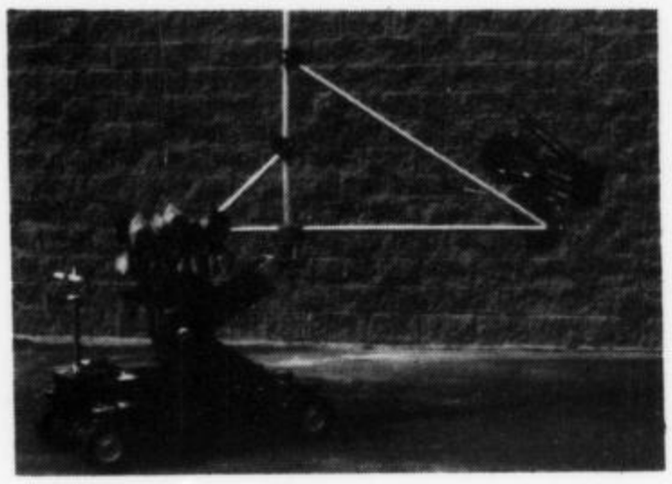
Professional videotape cleaner/inspector/rewinders are available from RTI, 4700 Chase Ave., Lincolnwood, IL 60646-1689. Tapechek Series 400 units clean and polish tapes, removing loose oxide and dirt. The units inspect a two-hr movie in only two mins, finding tape damage and grading the tape as in A, B, or C condition. A tape information display shows tape length in minutes and the number and location of any physical defects. An optional printer output automatically produces hard copy reports of tape condition.

RTI Tapechek 400 Series unit



Nemal Electronics audio snake cables

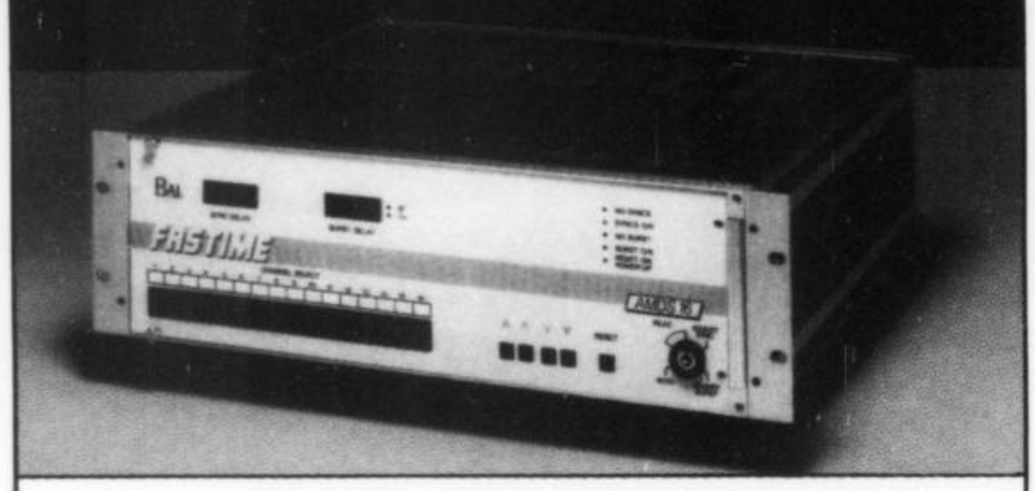
A line of multipair audio snake cables has been made available by Nemal Electronics International, Inc., 12240 NE 14th Ave., N. Miami, FL 33161. The cables are available in 2 through 24 pair constructions, all of which comply with the new National Electric Code CL2 requirements. Each pair consists of two 22-gauge stranded conductors plus a drain wire, foil shield, and individually numbered jacket. They are available in bulk as well as precut terminated lengths.



Mitchell Plate adapter by Kinetic Support Systems

An adapter coupling for the Mitchell Plate has been introduced by Kinetic Support Systems, 29210 Pointe O Woods Place, Suite 205, Southfield, MI 48034. The product allows the VCM F189 camera/equipment mount to be used to offset a camera from a dolly farther than a traditional offset device. It attaches to a Mitchell Plate using a giant threaded steel pin and steel nut. Few components are needed to provide rigid support through triangulation and counter weights are used to provide a balanced load.

IN A HURRY?
AUTOMATE TIMING
WITH FASTIME.



- Automatically adjusts delay for sync timing up to 1575 Nanoseconds.
- Burst timing automatically adjusted.
- Automatically times 16 channels in less than 60 seconds.
- Delay settings are stored during power failure or maintenance, even if cards are removed from rack.
- Manual fine trim is available on each channel.
- Allows manual selection and timing adjustment of each channel.

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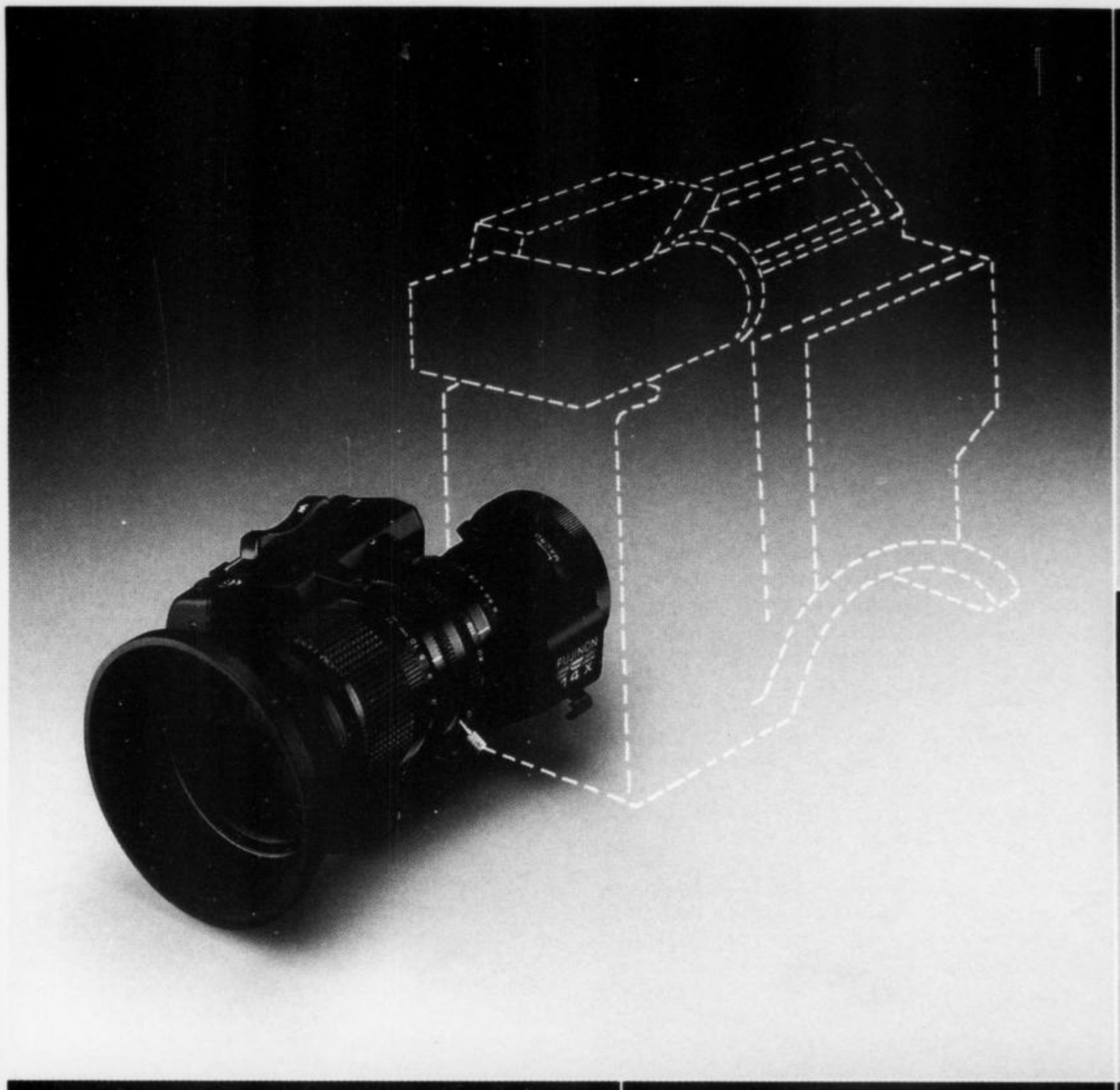

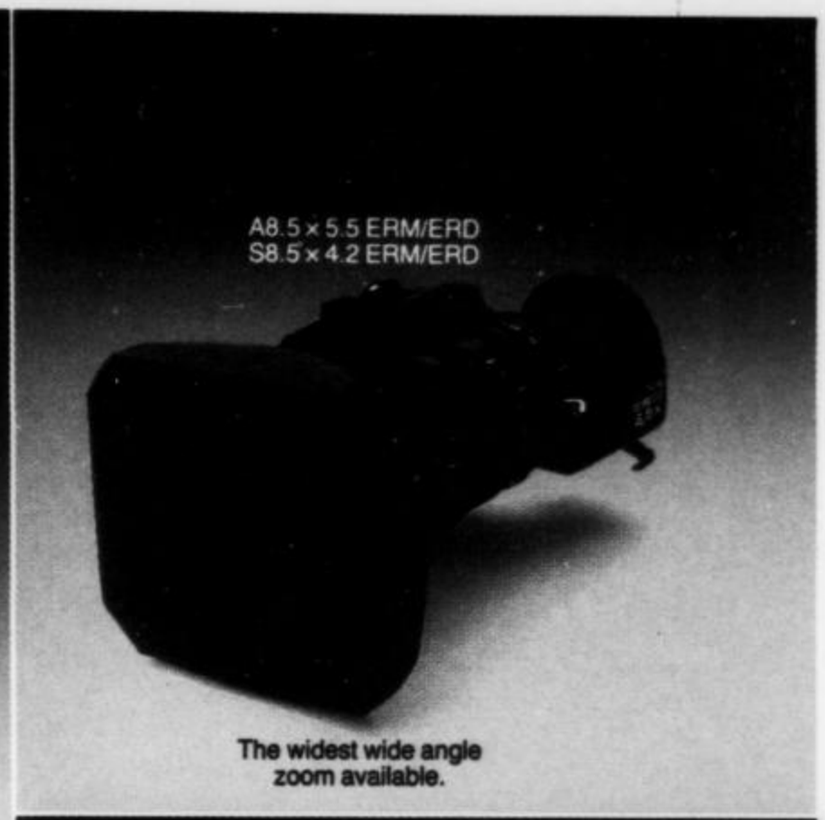

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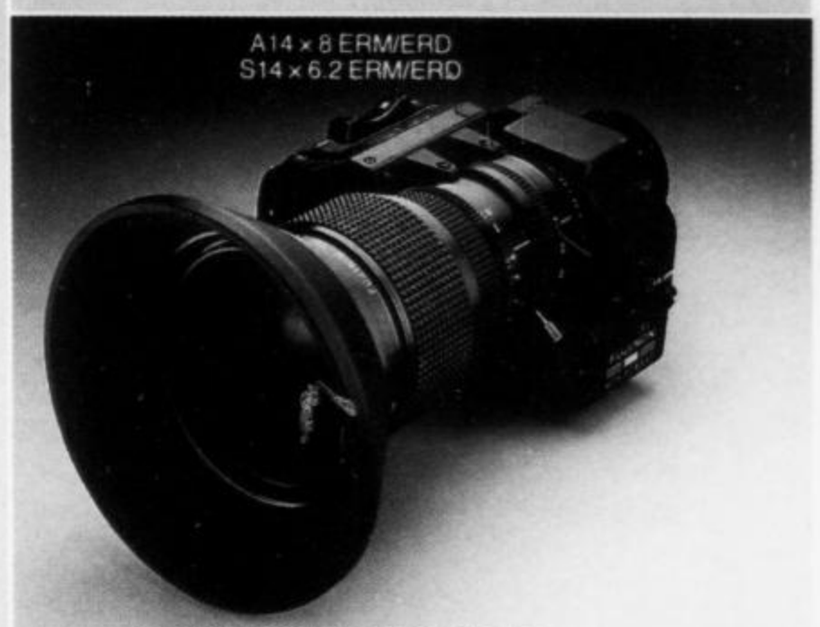
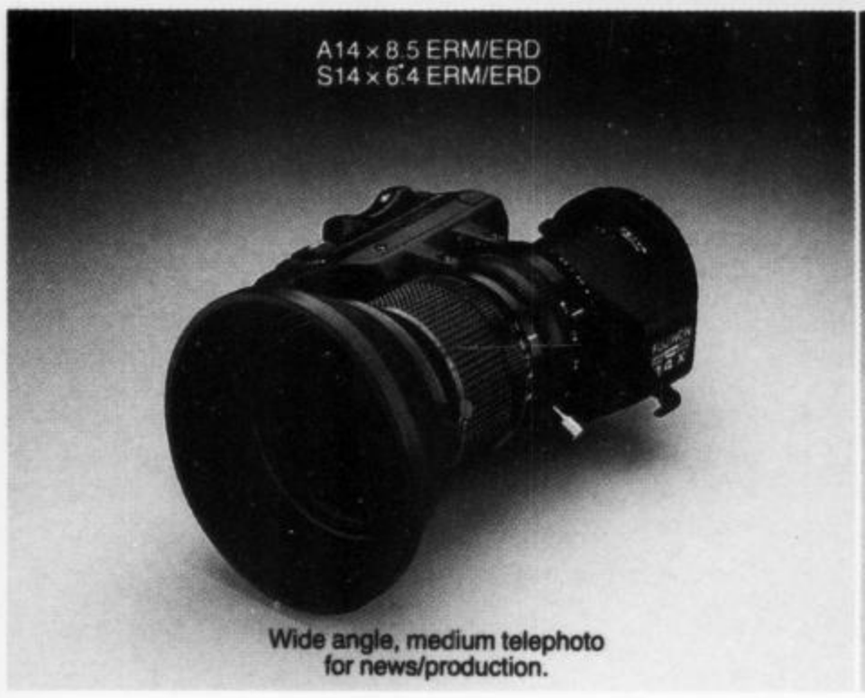
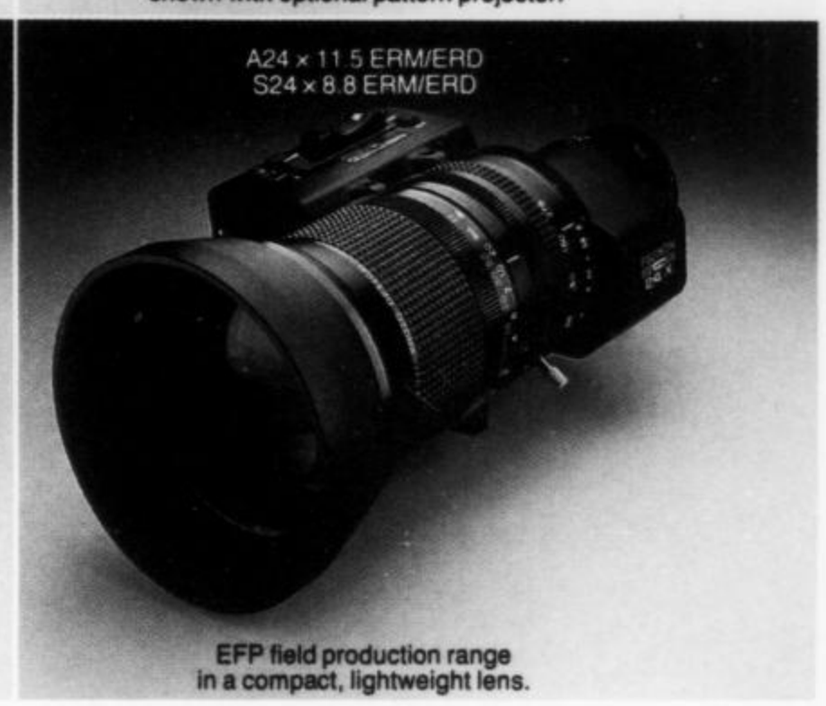


Ultra high resolution production lens shown with optional pattern projector.



Wide angle, medium telephoto for news/production.

Wide angle, long focal length for news/sports coverage.



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Employment Service

These notices are published for the service of the membership and the field. They are inserted for three months, at no charge to the member. The Society's address cannot be used for replies.

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Journals Available/Wanted

These notices are published as a service for members to expedite disposal and acquisition of out-of-print journals. Please write directly to the persons and addresses listed.

Available. Single Issues: *Transactions of the Society of Motion Picture Engineers*, #15, October 1922. *Journals of the SMPE*, February 1930, January 1932, February 1935, Index 1936 to 1945, October 1947, and February 1949. *Journals of the SMPTE*, March 1953 and February 1954. Best offer for each. Contact Les Holmes, 114 Neddie Dr., Scarborough, Ont. M1T 3S3, Canada, (416) 292-3773.

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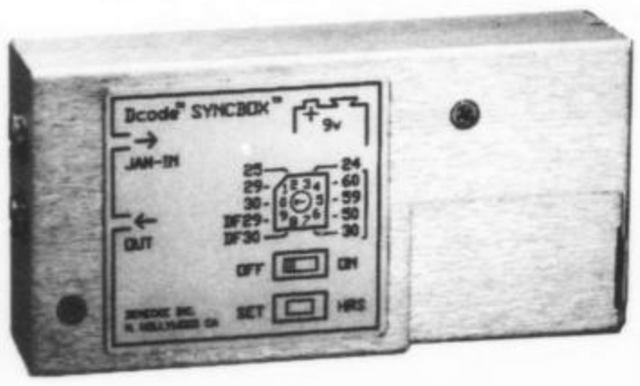

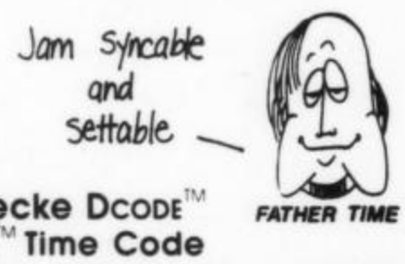

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Although many papers published in the *Journal* have been presented at SMPTE Technical Conferences, contributed papers are welcome. Manuscripts and all other materials for publication should be sent to:

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595 West Hartsdale Avenue
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Review: Every paper submitted to the SMPTE is reviewed by the Society's Board of Editors. The identities of the reviewers remain confidential so they may feel unconstrained in their evaluations. Every paper is sent to three or four reviewers who are knowledgeable in the subject of the paper. Once the paper is reviewed, the editor informs the author of its acceptance or rejection. On the basis of the reviewers' remarks, the editor often suggests revisions to improve the paper. In addition, every manuscript undergoes copyediting and styling by the editorial staff, to ensure accuracy, consistency, and readability.

Content: The *Journal's* primary objective is to follow the progress of motion-picture and television engineering and developments in allied fields. Controversial papers are welcome, providing they are substantiated by reliable data.

Technical articles must be informative and well-organized. They must record original work, or review previous work, giving proper credit. Results of actual experience and research should be given. Commercialism is unacceptable.

Preparation of Manuscripts: Manuscripts should be typewritten in black on one side of 8½ × 11-in. (22 × 28-cm) paper with 1½-in. (4-cm) margins. *All material, including abstract, main text, references, figure captions, and tables, should be double-spaced.* Number all pages consecutively.

To accelerate the reviewing of manuscripts, an original copy and three good-quality photocopies of all text and illustrations are requested.

Title Page: The author's first and last name should appear at the top of the first page. Next should be a citation in the appropriate form: 1. Presented at (conference) in (city) on (date) by (author), (author's affiliation, address), *or* 2. A contribution submitted on (date) by (author, affiliation, address). At midpage the title should appear—succinct, accurate, and suitable for later indexing.

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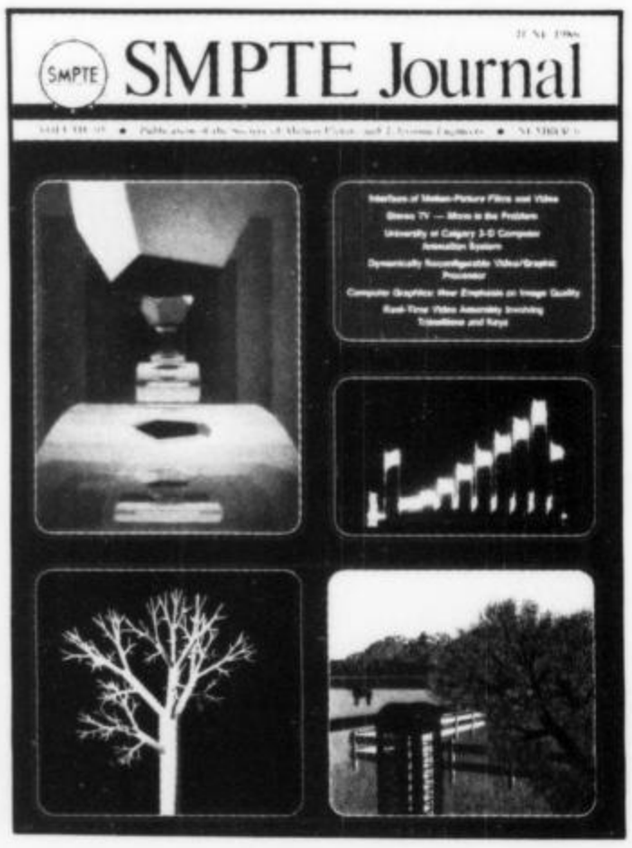

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A clearly defined interest in any phase of motion pictures and television is the principal requirement for membership in the SMPTE. There are various grades of membership corresponding to the individual's age and qualifications.

Active Member

An individual is eligible for admission to this grade if at least 25 years of age, is recommended by an Active, Fellow, or Honorary Member of the Society, and meets at least one of the following requirements:

1. An individual engaged in the motion-picture, television, or allied arts and sciences, who has performed or been responsible for engineering or scientific work therein for a period of at least three years; or

2. A teacher in a school of recognized standing who has conducted for at least three years a major course principally concerned with motion-picture or television engineering or a subject involving the related arts and sciences; or

3. An individual who has made a distinct contribution to the advancement of engineering or science in motion pictures, television or the allied arts and sciences, or has contributed to the technical literature thereof, or has made significant inventions therein; or

4. An individual who for at least three years has had, under his/her executive direction, important engineering work in motion pictures, television or the related sciences, and who is otherwise qualified for direct supervision of the technical and scientific features of such work.

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***Qualifications (Active only).** Refer to Active member requirements on this page and describe your qualifications below, giving dates. Please circle if you are applying under requirement 1, 2, 3 or 4. If more space is needed, attach an additional sheet.

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Associate Members may vote in Section elections but cannot hold office. They may serve on any Committee of the Society as members (but not as chairmen) and may vote on any matter before the Committee.

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An applicant must be registered for a least a half-time program in a college, university or other recognized educational institution, and must evidence interest in the study of technology involved in motion pictures, television or the related arts and sciences. Students must be recommended by an SMPTE member or by a faculty member of the applicant's college (who need not be an SMPTE member).

For Student Membership

An SMPTE Member, or any faculty member of the student's institution, can satisfy the reference requirement by signing the statement below.

I hereby certify that the above applicant is registered as a student in a regular course of study for at least a half-time program, and has an interest in the technology of motion pictures, television, or the related arts and sciences.

Signature _____

Print Name _____

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Why Belong to the SMPTE?

The SMPTE is the most important organization serving motion pictures and television. Membership in SMPTE can help you learn more about your field through the *SMPTE Journal.* SMPTE Conferences, and local section meetings. It can also help you meet others in your field, who are interested in the same things you are, no matter what area of motion pictures and television you are employed in.

It is common knowledge that membership in a professional organization can have an important influence on your career, not only because of what you can learn, but by who you can meet. In a recent SMPTE survey, more than 90% of those responding said the SMPTE is helpful in their jobs. The high esteem the SMPTE is held in both motion pictures and television is evidenced not only by the range of individual members, but by the number of companies supporting the SMPTE through Sustaining Membership. There are more than 230 such companies.

Here's what you get when you join the SMPTE:

1. You receive the monthly *SMPTE Journal.* The *Journal's* normal subscription price to non-members is $55.00. You get it free as part of your membership.

2. The SMPTE has local sections (chapters) which hold monthly meetings throughout the U.S. and Canada. You are encouraged to attend these meetings to meet with other professionals in your locale and participate in programs of interest and importance.

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The SMPTE draws its members from professionals in two primary fields: motion pictures and television. The membership is made up of people who are involved in all areas of these industries. For example, in motion pictures, SMPTE members include engineers and technicians; producers and directors; people in sound recording, lighting, optics and audio-visual; cameramen; film editors; projectionists; service engineers; sales and marketing people; teachers, instructors, and professors; consultants; and executives. The companies they work for include manufacturers, distributors and dealers of motion picture equipment; film laboratories; film studios; companies using film as a tool (business and industry); theaters and theater chains; and governmental and educational institutions.

Members in the television field are largely engineers; chief engineers; technicians; TV producers and directors; production people; and executives. Most of the TV people are involved with engineering, production, sales and management. The TV members work for TV networks; local stations and group stations; manufacturers and suppliers of TV equipment; companies using TV as a tool (business and industry); TV studios; production houses; and governmental and educational institutions.

Many SMPTE members work in both fields, such as audio-visual people, and those in TV news, equipment manufacturing, laboratories and production houses.

If you work in any facet of motion pictures and television, there is a place for you in the SMPTE. Join today!

Standards and Recommended Practices

Approved SMPTE Engineering Guidelines

Two SMPTE Engineering Guidelines were approved by the Society's Executive Committee for Standards Approval: EG 5-1989, Projected Image Quality of 70-mm, 35-mm and 16-mm Motion-Picture Projection Systems; and EG 18-1989, Design of Effective Cine Theaters. These and other SMPTE Engineering Guidelines may be obtained from Society Headquarters for $3.00 each.

Proposed American National Standards

Parameters for ½-in Type M-2 television analog recording were approved by the Society's Working Group on ½-in Component Analog Formats, the Television Recording and Reproduction Technology Committee, and the Standards Committee. Published here for a trial period and public review are SMPTE 249M, Television Analog Recording — ½-in Type M-2 — Records; SMPTE 250M, Television Analog Recording — ½-in Type M-2 — Tapes and Cassettes; SMPTE 251M, Television Analog Recording — ½-in Type M-2 — Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control; and SMPTE 252M, Television Analog Recording — ½-in Type M-2 — Pulse Code Modulation Audio.

Proposed SMPTE Recommended Practice

Also published for a trial period is a Proposed SMPTE Recommended Practice RP 158, Basic System and Transport Geometry Parameters for ½-in Type M-2 Format.

Copies of all the proposals are available from Society Headquarters for $3.00 each. Comments should be addressed to Sherwin H. Becker, Director of Engineering, at Society Headquarters. The proposals will be submitted to the Executive Committee for Standards Approval if no adverse comments are received by August 1, 1990.

Reaffirmed SMPTE Recommended Practices

The Society's Executive Committee for Standards Approval reaffirmed three SMPTE Recommended Practices: RP 50-1985, Dimensions for 8-mm Type S Motion-Picture Projector Reel Spindles; RP 58-1974, Nomenclature for Devices Enclosing 8-mm Motion-Picture Film for Projection; and RP 129-1985, Requirements for 35-mm, 16-mm and 8-mm Type S Tape Splices on Magnetic Audio Recording Motion-Picture Film. All three practices were reaffirmed in 1990. These and other SMPTE Recommended Practices are available from Society Headquarters for $3.00 each.

— Sherwin H. Becker, Director of Engineering

SMPTE Standards Subscription Service

The Society provides a Standards Subscription Service to assist firms, libraries, and individuals in establishing and maintaining a complete and current file of approved American National Standards, SMPTE Recommended Practices, and SMPTE Engineering Guidelines in the motion-picture, television, and video magnetic recording fields. Through this service, the Society makes automatic distribution to standards subscribers of all new and revised standards, recommended practices, and guidelines that are approved during the calendar year in these fields.

For further information, write to: Standards Subscription Service, Engineering Dept., Society of Motion Picture and Television Engineers, 595 West Hartsdale Ave., White Plains, NY 10607.

SMPTE ENGINEERING GUIDELINE

EG 5–1989

Projected Image Quality of 70-mm, 35-mm and 16-mm Motion-Picture Projection Systems

Introduction

The Committee on Theatrical Projection Technology decided that, with the availability of appropriate test films, a guideline should be developed to assist those interested in determining the degree of acceptability of image quality regarding the apparent sharpness of the projected image. Although factors such as image contrast, color fringing, and image steadiness are not covered, their effect on apparent sharpness should be considered.

1. *Scope*

This guideline specifies the conditions for the determination of image sharpness of 70-mm, 35-mm, and 16-mm motion-picture projection systems. It also classifies the practical limits of acceptability of image sharpness when using projector alignment test films. (See Appendix A2.)

2. *Test Conditions*

This guideline is based on the assumption that the classifications specified are those to which the projection system has been adjusted as specified in SMPTE Recommended Practice on Method for Determining the Degree of Jump and Weave in 70-, 35- and 16-mm Motion-Picture Projected Images, RP 105-1989; and that the screen luminance has been adjusted to be in accord with American National Standard for Motion-Picture Film — Screen Luminance and Viewing Conditions — Indoor Theater Projection, ANSI/SMPTE 196M-1986.

3. *Definitions*

3.1 Resolution is the apparent sharpness determined by the ability of a system to reproduce a specified number of equally spaced black lines and white spaces in groups which are at right angles to each other. (In television terminology, resolution is described by counting line pairs, a black line and a white space, as a single unit.)

3.2 The viewer's impression of resolution is related to the apparent size of the screen image. The apparent size of the screen image may be divided into three classifications:

Large: A large appearing screen image is one which is viewed from a distance of 3.7 screen heights or less (vertical field of vision is 15° or greater).

Medium: A medium appearing screen image is one which is viewed from a distance of 3.7 to 5.7 screen heights (vertical field of vision is between 10° and 15°).

Small: A small appearing screen image is one which is viewed from a distance of greater than 5.7 screen heights (vertical field of vision is 10° or less).

4. *Method*

Project an appropriate test film containing resolution targets calibrated in line pairs per millimeter (see A2), using the projection format with the greatest horizontal magnification (usually anamorphic for 35-mm projection).

Examine the projected image closely (see A1), considering only the vertical line pairs in the resolution target, since the horizontal line pairs are affected by system unsteadiness (jump) to a degree which makes them unreliable for resolution evaluation.

A line pair is considered to be clearly recognizable when the individual lines in the pattern can be clearly distinguished and the number of lines seen in the pattern is the same as the number of lines in the original target.

5. *Classification*

For each classification of apparent size of the screen image, the practical minimum limit of acceptability in terms of clearly recognizable lines per millimeter shall be as follows:

Classification	Lines per Millimeter Center	Sides*	Corners
Large appearing screen image (Review rooms, premier theaters)	80	56	48
Medium appearing screen image (First-run theaters)	68	56	40
Small appearing screen image	56	48	40

*Assumes left and right sides equivalent at same focus setting.

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Revision of EG 5-1982
Approved December 19, 1989

Appendix

(This Appendix is not part of the SMPTE Engineering Guideline, but is included for information only.)

A1. Judgment of screen image resolution must be made from areas closer to the screen than those generally considered the best for viewing and definitely not from the rear of the theater or projection room.

A2. Appropriate test films are SMPTE 35-PA, as specified in SMPTE Recommended Practice RP 40-1971 (R1989), Specifications for 35-mm Projector Alignment and Screen Image Quality Test Film; SMPTE 70-PA, as specified in SMPTE Recommended Practice RP 91-1987, Specifications for 70-mm Projector Alignment and Screen Image Quality Test Film; and SMPTE 16-PA, as specified in SMPTE Recommended Practice RP 82-1985, Specifications for 16-mm Projector Alignment and Screen Image Quality Test Film.

SMPTE ENGINEERING GUIDELINE

EG 18–1

Design of Effective Cine Theaters

1. *Introduction*

Present-day cinema technology provides the motion-picture theater exhibitor with projection and sound equipment capable of displaying high-quality images with clean, full-frequency sound. Yet, many patrons are denied this full realization of the film producer's art because the theater designer has failed to provide the proper environment for experiencing the wonderful world of illusion that is the art of cinematography. Good design has often been compromised by "practical" solutions and the belief that effective cinemas are not economically feasible. Contrary to this belief, many effective cine theaters have been designed for museums, universities, visitor centers, and Worlds Fairs by creative teams of architects, acousticians, and motion-picture engineers at reasonable cost. Similar results could be achieved for the film exhibitor by architects and their consultants based on the parameters and criteria contained in this guideline.

The effective cine theater is a place in which everyone can see and hear well. The summary lists the architectural parameters which must be addressed by the designers and the criteria recommended here.

2. *Image Size*

Although there is validity in discussing image size in terms of visual acuity or camera lens perspective,

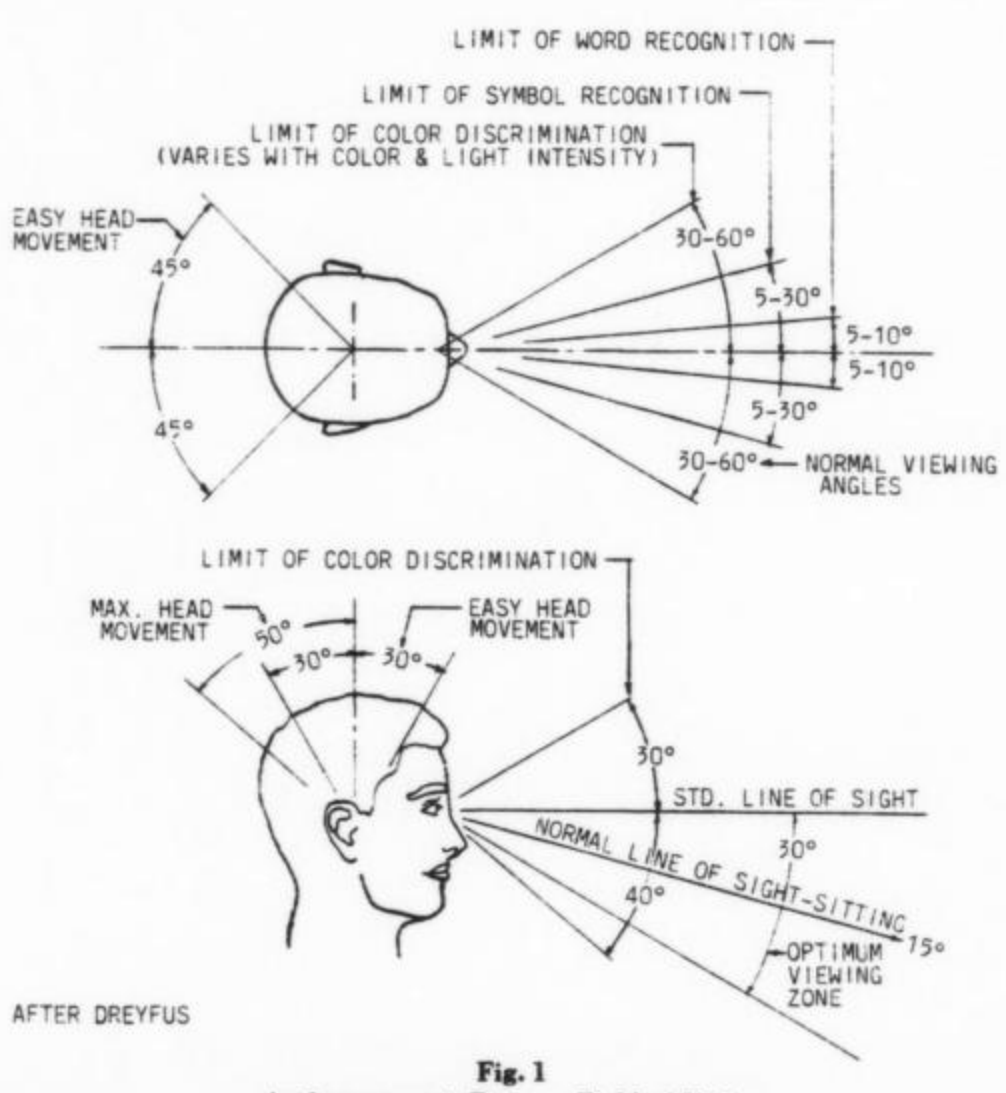

Fig. 1
Anthropometric Data — Field of Vision

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criterion in terms of how much of the viewer's field of vision is occupied by the image may be more responsive to the filmmaker's intent and the viewer's subjective impression.

The anthropometric data[1] shown in Fig. 1 suggests that the screen appears large when it occupies a substantial portion of the viewer's horizontal and vertical field of vision. Experience indicates that the screen image will appear small if the image occupies less than 15° of the viewer's vertical field of vision or approximately 30° of the horizontal field of vision. Geometry for determining the viewer's field of vision is given in Fig. 2 and an analysis of some selected viewing distances are given in the Appendix.

3. *Viewing Angle Distortion*

It is evident that as the viewer's line of sight to the screen deviates from the perpendicular, circles become ellipses, squares become rhombuses, and all shapes become distorted (Fig. 3). This subject was treated in detail by Dr. Reubens Meister,[2] who concluded that 45° was the limit of tolerable viewing-angle distortion. He provided a simple geometric construction for outlining the seating area which falls within the prescribed limits (Fig. 4), which he termed iso-deformation lines.

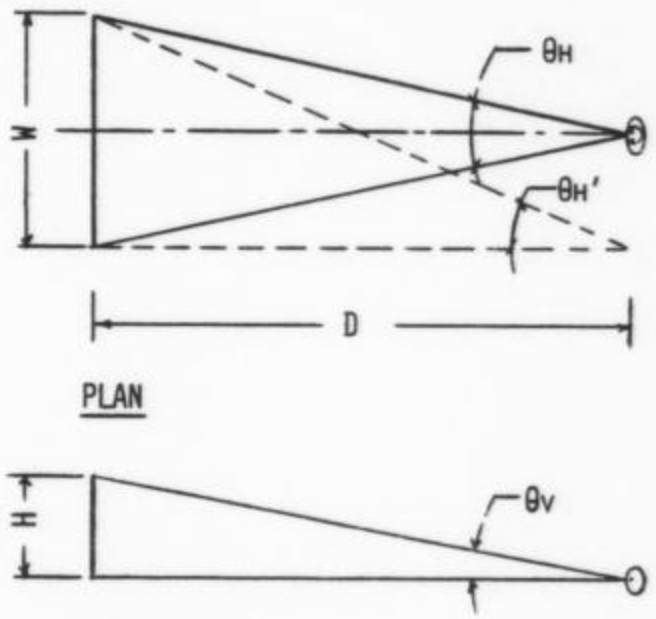
4. *Visibility*

To see well, every viewer should have an unobstructed vertical and horizontal sightline to the image on the screen (Figs. 5 and 6). If screen images are to fill 30° of the most distant viewer's field of vision and up to 80° of the nearer viewer's, it is evident that looking between the heads of the row immediately ahead, as in 2-row vision, does not permit a view of the entire screen. Thus 1-row vision is the most desirable for the effective cine theater.

Although the technique for determining the slope of the seating risers, using either drafting or analytical methods, is well known (Fig. 7), considerable confusion exists with respect to the value given (c), the so-called eye-to-top-of-head dimension. Whereas the actual eye-to-the-top-of-the-head distance is fairly constant at 4.3-in average (range = 3.5 in to 4.6 in), the location of a seated person's eye with respect to the top of the head of the person in front differs from the average (Fig. 8). Thus, if the riser height is to be determined by $Yn - K$, K = 3 ft 8 in typically, then the value of c must be obtained from $c = A - B$ (Fig. 8). It is recommended that c = 9 in to 10 in to be used in the analytical method. Cramer and Booth[3] have shown that when c = 7 in, the probability will be that 80% of the viewers will have satisfactory 1-row vision. It is suggested that c = 7 in as a minimum.

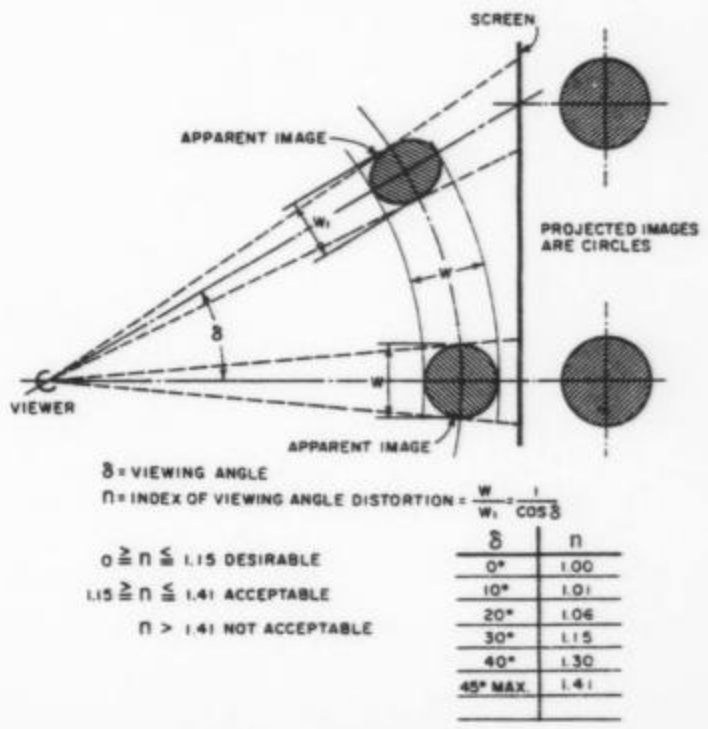
Since the floor slope will also be determined by the location of the aiming point (O), and the location of the front row of seats (X1), the placement of the bottom of the screen is important. Experience has shown that 4 to 6 ft above the first row of seats is satisfactory, provided a 6-ft standing person does not interrupt the projection beam. If no subtitles are to be used, the aiming point may be placed approximately 10% of the image height above the bottom of the image. This superimposes the heads in front onto the screen, which some viewers find desirable. If subtitles are to be used, the aiming point should be the bottom of the screen image.

The plot of the equation in Fig. 7 is a parabolic curve whose slope will usually exceed the aisle slopes allowed by local codes. Steps in the aisle should then be used to obtain the required seating levels with appropriate transition segments to join aisles with the seating levels.



D = Most distant viewer
H = Image height (screen height)
W = Image width (screen width)
= K x H
K = Aspect ratio (format)
θ_H = Horizontal field of vision, degrees
= 2 x ARCTAN (½ W ÷ D)
θ_V = Vertical field of vision, degrees
= ARCTAN (H ÷ D)

Fig. 2
Geometry for Determining Viewer's Field of Vision Subtended by the Image



δ	n
0°	1.00
10°	1.01
20°	1.06
30°	1.15
40°	1.30
45° MAX.	1.41

Fig. 3
Viewing Angle Distortion

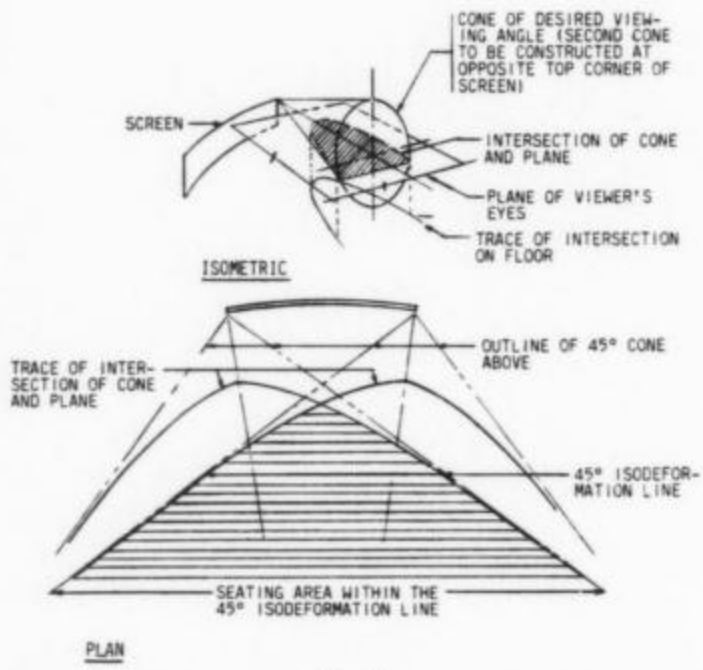

CONE OF DESIRED VIEWING ANGLE (SECOND CONE TO BE CONSTRUCTED AT OPPOSITE TOP CORNER OF SCREEN)
SCREEN
INTERSECTION OF CONE AND PLANE
PLANE OF VIEWER'S EYES
TRACE OF INTERSECTION ON FLOOR
ISOMETRIC
OUTLINE OF 45° CONE ABOVE
TRACE OF INTERSECTION OF CONE AND PLANE
45° ISODEFORMATION LINE
SEATING AREA WITHIN THE 45° ISODEFORMATION LINE
PLAN

Fig. 4
Construction of the Viewing Angle Iso-deformation Line

Row spacing (d) should be not less than 30 in back-to-back with 36 to 40 in providing greater comfort. The width of seats should be not less than 19 in with 20 to 21 in providing greater comfort.

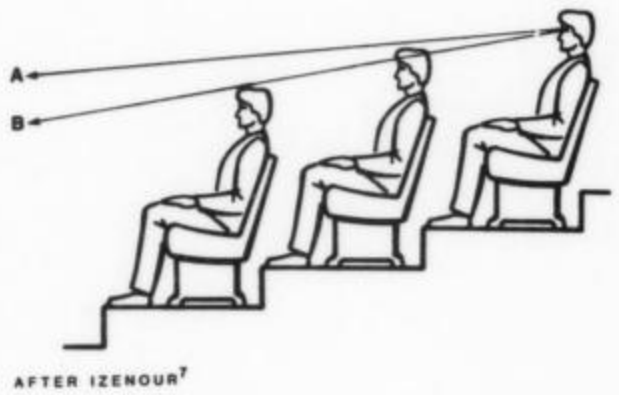
When 1-row vision is not feasible, seats should be offset as determined by a careful sightline study to the screen vertical centerline. The total number of seats in a row will be determined by local codes, nominally 14 or 15, unless wider continental seating is used. If seating layouts are done by the supplier, as is the usual case, the architect should ensure that the work meets these criteria.

5. *Comfort*

Although it is usually assumed that ventilation, heating, and cooling will provide for human comfort, frequently these conditions are compromised for reasons of economy. Thus operating costs must be considered during the design phase of the effective cine theater and accepted by the owner as an essential part of the theater's design.

In addition to ensuring that everyone will see well, seating in the effective cine theater must avoid physical discomfort, which occurs when the vertical viewing angle to the top of the screen image is excessive or the lateral viewing angle to the centerline of the screen requires uncomfortable head and/or body position.

Since the normal line of sight is 12 to 15° below the horizontal, seat backs should be tilted to elevate the normal line of sight approximately the same amount. For most viewers, physical discomfort occurs when the vertical viewing angle to the top of the screen exceeds 35°, and when the horizontal line of sight measured between a perpendicular to his seat and the centerline of the screen exceeds 15°. To compensate for excessive lateral viewing angles, the seat rows should be angled or curved as shown in Fig. 9.



A: 1-row vision = single-row vision = every-row vision. Vertical sightline passes over the heads of the persons in the first row ahead.

B: 2-row vision = double-row vision = every-other-row vision.
Vertical sightline passes between the heads of the persons in the first row ahead and over the heads of the persons in the second row ahead.

Fig. 5
Vertical Sightlines

Row Spacing	Seat Width 19 in	20 in	21 in
30 in	24.4	26.3	28.1
32 in	23.0	24.7	26.4
34 in	21.6	23.3	24.9
36 in	20.5	22.0	23.5
40 in	18.4	19.9	21.2
42 in	17.5	18.9	20.2

Fig. 6
Horizontal Viewing Angles in Degrees for 2-Row Spacing for Selected Seat Widths and Row Spacings

6. *Projection Angle Distortion*

When the projector is placed in a position other than normal in relation to the screen, shapes are distorted as shown in Figs. 10 and 11. Note that the equation shows distortion to be a function of screen size, projection distance, and the projection angle. Experience suggests that 5% is a tolerable maximum limit for projection angle distortion, with 3% preferred.

7. *Architectural Distractions*

In 1947, Ben Schlanger, an eminent cinema architect, said, "What we need is a theater in which a person can sit down and look at a picture and not be conscious of the physical shelter in which he is enjoying the picture."[4] That dictum is valid today.

When the picture illuminates the screen, the light from the screen illuminates the walls and ceiling as well as the seating area. Nothing in the room's decor should distract the viewer's attention from the projected image. This does not say that the interior cannot be made to appear attractive and inviting. However, interior finishes should be non-reflective and of low chrominance. Varying the intensity of colors so that the darkest hues are in the vicinity of the screen has proved effective.

The question whether the screen should be masked in black or be "free floating" is a matter of preference. In theaters using more than one film format, the need for variable masking would lead to the choice of black masking all around. Aisle lights and exit signs required by safety codes can be a serious source of distraction, and circulation patterns for patrons entering and leaving may cause undue distractions. These architectural elements must be carefully evaluated in the design of the effective cine theater.

8. *Acoustical Environment*

Technical advances in film sound recording and reproduction make it increasingly apparent that the acoustical environment of the cine theater is critical to the patron's full enjoyment of modern films. Recent research indicates that special consideration must be given to the following:

Freedom from flutter echo, spurious room resonances, and focusing.

Special absorptive treatment of the wall behind the screen loudspeakers and the rear wall of the theater to avoid undesirable reflections and phase cancellations.

Elimination of those elements considered desirable in the live theater, which preferentially support the loudness and "color" the sound of live music.

Background noise: The noise level in the theater due to air conditioning and other mechanical sources must be equal to or less than the Noise Criteria Curve NC30 of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) for each octave band. Details of measurement methods and maximum noise levels are given in SMPTE Recommended Practice RP 141-1986, Background Acoustic Noise Levels in Theaters and Review Rooms.

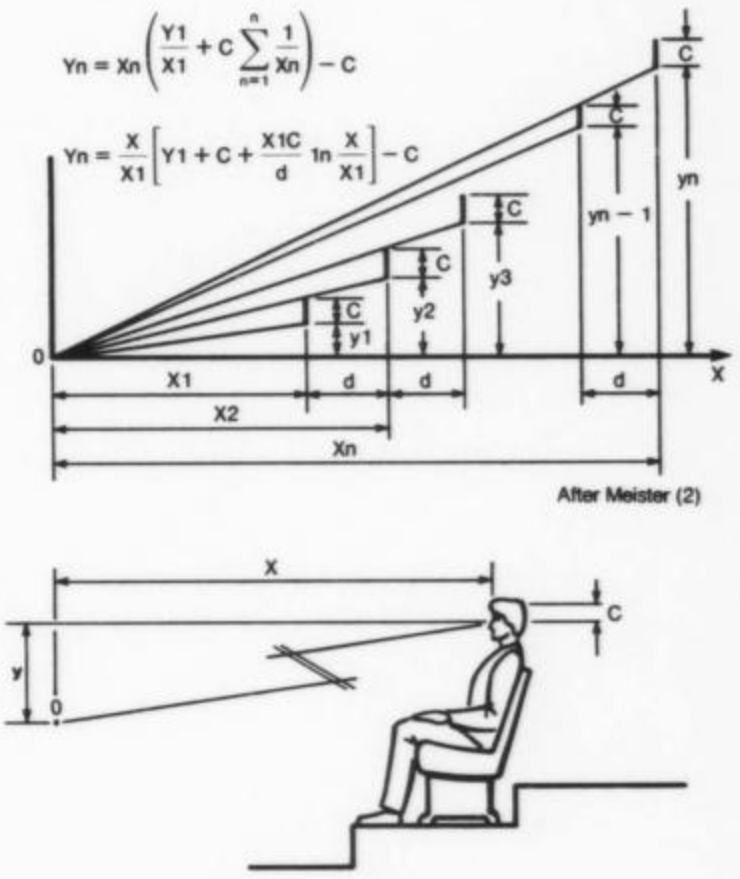
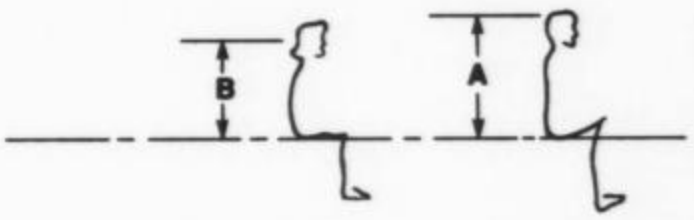


Fig. 7
Analytical Method for Sightline Study



	A* Seat to Top of Head (Inches)		B* Seat to Eye Level (Inches)	
	Female	Male	Female	Male
Large	34.9	38.5	30.2	33.9
Average	32.9	36.0	28.8	31.5
Small	29.7	33.4	26.3	29.0

A-B	A = Large male B = Small female	12.2 in Without slump 14.2 in With slump
A-B	A = Average male B = Average female	7.2 in Without slump 9.2 in With slump
A-B	Per classic texts on theater design	4-5 in (10—12.8 cm)

*After Dreyfus[6] and Jones[8]

Fig. 8
Anthropometric Data for Sightline Study

Acoustical isolation: To eliminate objectionable noise from adjacent theaters (in the case of multiples), the projection booth and outside sources, walls, ceilings, floors, and doors must be designed with suitable noise reduction based on industry standard sound transmission class (STC) ratings in the mid-60s and 70s. A table summarizing published information[5] is reproduced in Table 1 to guide the acoustician. A local survey of ambient street and overflight noise should also be available.

Reverberation: Fig. 12 shows preferred reverberation time for the 500 Hz octave band.[5] Ideally, the reverberation time would be equal for all frequencies. Although this is not realizable in most motion-picture theaters, the acoustician should strive to achieve a smooth decay for all frequencies with an absence of bass "overhang."

Loudspeaker position: For reproduction of multitrack sound records in theaters showing 35-mm 1.85:1 and 2.35:1 formats, it is recommended that when three behind-the-screen speakers are used they be positioned as required for the 2.35:1 format and that acoustically transparent material be used on the trailing edges of the 1.85:1 masking.[5] Alternately, five loudspeakers may be used behind the screen, two of which are positioned for the 2.35 format, and two for the 1.85, with one pair switched off, depending on the format being used.

Equalization: Whether ⅓-octave band equalization will be required in the film sound B chain is a decision to be made by the motion-picture engineer or acoustician. When equalization is required, the house curve characteristic shall be as described by Curve X in American National Standard for Motion-Pictures—B Chain Electro-Acoustic Response—Control Rooms and Indoor Theaters, ANSI PH22.202M-1984, or as specified by the equipment manufacturer.

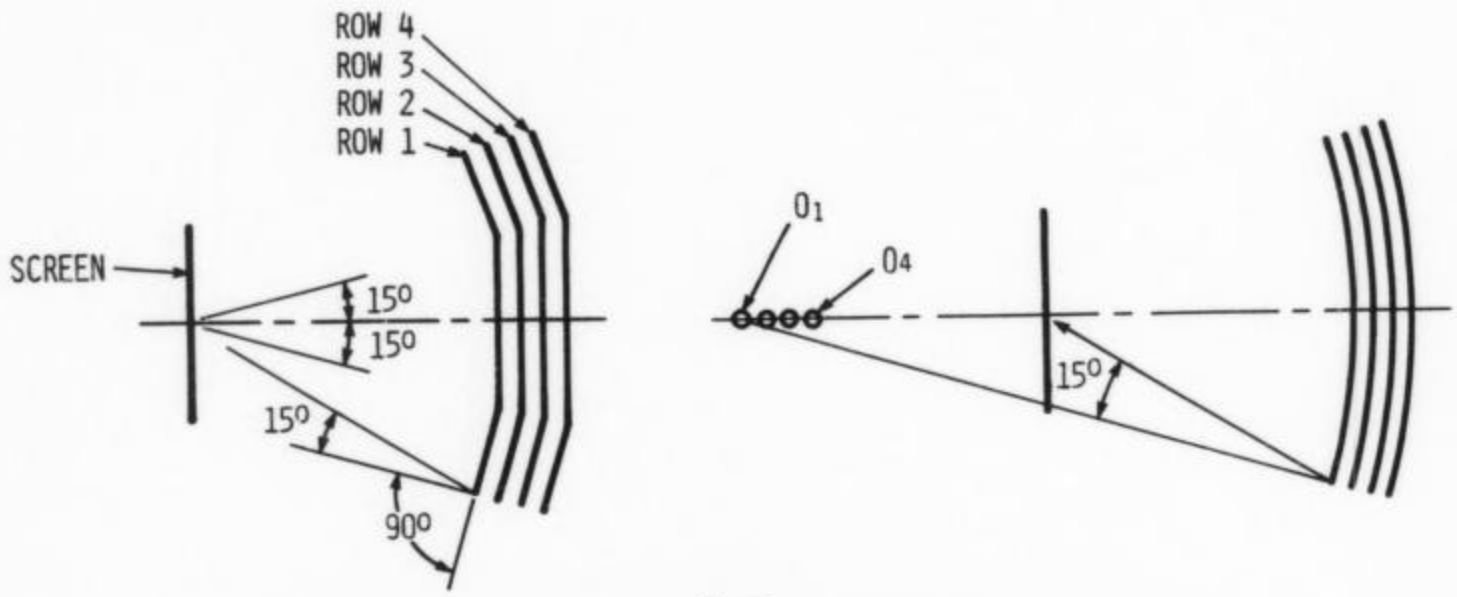


Fig. 9
Construction for Seating Row Angle and Seating Row Radius of Curvature

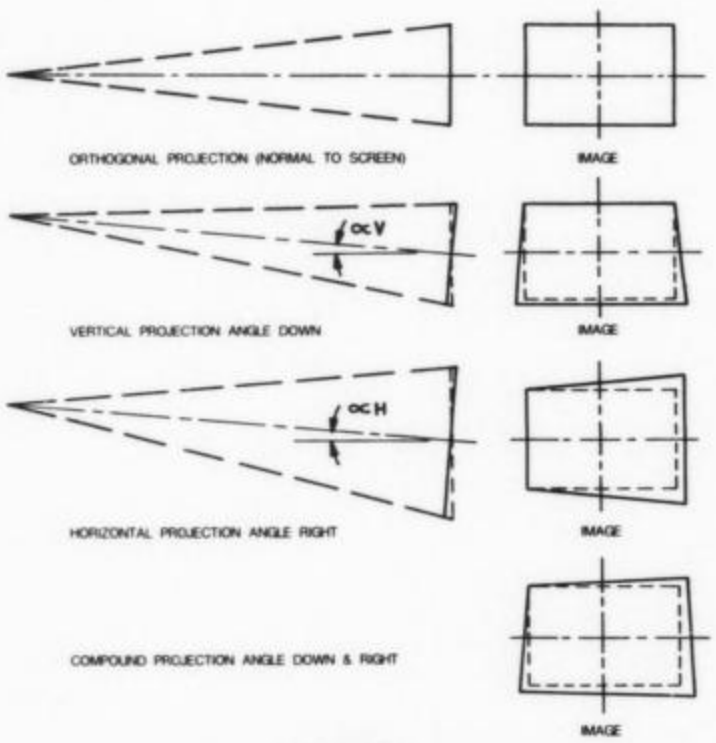


Fig. 10
Projection Angle Distortion

Summary

A. The effective cine theater is a place where everyone can see and hear well.

1. *Image Size.* How large should the screen image be?

The image on the screen should subtend not less than 15° of the most distant viewer's vertical field of vision, and approximately 30° of his horizontal field of vision.

2. *Viewing Angle Distortion.* What is the tolerable limit of distortion due to the position of the viewer with respect to the projected image?

All seats should be contained within a 45° iso-deformation line.

3. *Visibility (Seating Risers and Sightlines).* Does every viewer have an unobstructed horizontal and vertical sightline to the projected image?

Seating slopes and/or seating risers should be designed for 1-row (single-row) vision. If 2-row vision is used, seats should be staggered.

When using the analytical method, the value of *c*, the so-called eye-to-top-of-head dimension, should be 9 to

10 in and not less than 7 in; the aiming point should be the bottom of the screen when subtitles are to be used, or 10% of the image height above that point when no subtitles will be used.

Rows should be spaced not less than 30 in back-to-back with 36 to 40 in preferred unless otherwise required by code (for continental seating).

Seats should be not less than 19 in side-to-side, with 20 in preferred. (For pseudo-staggered seating, use 19, 20, and 21 in.)

4. *Comfort.* Is the ventilation, heating, and cooling capacity adequate for continuous human comfort? Does the design of seats provide a natural posture for viewing the projected image? Does the vertical viewing angle to the top of the projected image require an uncomfortable head position? Does the lateral viewing angle to the centerline of the screen require an uncomfortable head and/or body position?

HVAC systems should be designed and operated for patrons' comfort whenever the theater is occupied.

Seat backs should be tilted approximately 12° to raise the normal downward line of sight to the horizontal.

The nearest viewer's vertical line of sight should not exceed 35° from the horizontal to the top of the projected image, and preferably should be 15° to the horizontal centerline of the screen image.

For the side seats, the lateral line of sight to the screen centerline, measured from a perpendicular to the seat row, should not exceed 15°.

5. *Projection Angle Distortion.* How much is the image distorted due to the position of the projector (projection angle)? What are the tolerable limits of distortion?

Image distortion due to the horizontal or vertical projection angle should not exceed 5%, and 3% maximum is preferred.

6. *Architectural Distraction.* Do any of the theater's interior architectural features distract the viewer's attention from the projected image?

Interior finishes, lighting required for safety, and patron traffic should be designed to minimize distractions for the patrons viewing the screen.

7. *Acoustical Environment.* Do the theater's acoustics ensure that everyone will hear well?

The theater should be free of flutter echo, spurious resonances, focusing, and all elements which will preferentially support loudness or color the sound.

Background noise from all sources should be equal to or less than NC30 in all octave bands.

Acoustical isolation from sound sources in adjacent spaces must be adequate to preserve the noise criteria (NC30) requirements.

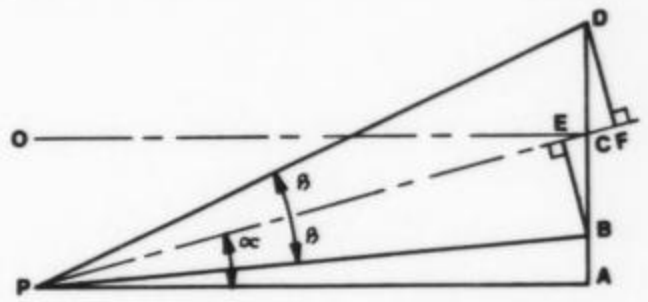
Reverberation time at 500 Hz should be optimized for the room volume, with smooth decay at all frequencies and absence of bass "overhang."

Loudspeakers for multi-channel sound should optimize the stereo aspects of the sound records.

Equalization, when used, should provide a "house curve" conforming to ANSI PH22.202M-1984.

B. The effective cine theater is a place in which state-of-the-art projection technology is employed.

1. *Screen Design.* Are the screen shape (flat or curved) and material (matte or gain) appropriate for the viewing environment?



H = Image height H′ = Aperture height
W = Image width W′ = Aperture width
FL = Lens focal length
L = PA = Projection distance
T = PC = Throw distance
CB + CD = H or W CE + CF = ΔT
α = Projection angle, vertical or horizontal
= ARCTAN (PO ÷ PA)
β = Projection beam half angle, vertical or horizontal
= ARCTAN (½ H′ ÷ FL), or
= ARCTAN (½ W′ ÷ FL)
% distortion = (ΔT ÷ T) x 100
For horizontal projection angle:
% distortion = [(W x sinα x cosα) ÷ L] x 100
= [(W x sinα) ÷ T] x 100
For vertical projection angle:
% distortion = [(H x sinα x cosα) ÷ L] x 100
= [(H x sinα) ÷ T] x 100

Fig. 11
Formulas for Determining Projection Angle Distortion

Table 1
Recommended Noise Reduction Between Adjacent Theaters (dB)[5]

31.5 Hz	63 Hz	125 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
38	48	52	66	66	66	66	66

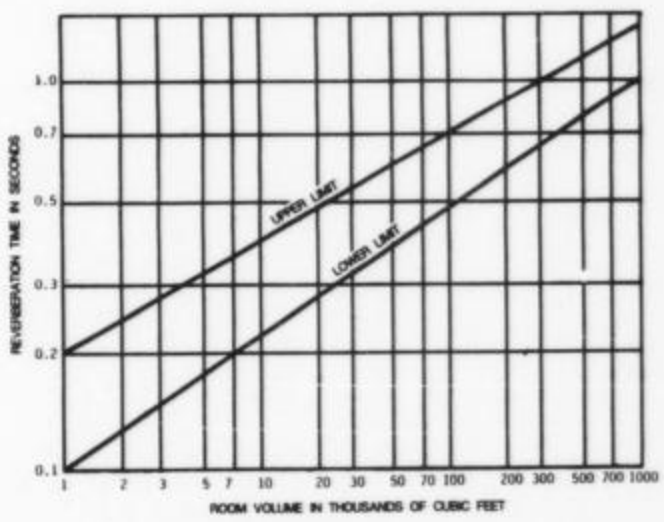


Fig. 12
Recommended Reverberation Time for Motion-Picture Theaters

2. *Screen Brightness.* Is the picture brightness (screen luminance), contrast ratio, and color balance according to SMPTE Standards?

3. *Picture Steadiness.* Do the projectors provide picture steadiness (jump and weave) and freedom from "breathing" and "ghosting" in accordance with SMPTE Standards?

4. *Picture Sharpness.* Are lenses and lamphouses of modern design, and have they been properly matched to provide optimum image sharpness (acutance) according to SMPTE Standards?

5. *Sound System Characteristics.* Is the "B chain" of the sound system optimized for frequency response, wow and flutter, and distortion according to SMPTE Standards?

References

1. W. Szabo, "Some Comments on the Design of Large-Screen Motion-Picture Theaters," *SMPTE J.*, *85*:159-163, March 1976.

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Appendix

(This Appendix is not part of the SMPTE Engineering Guideline, but is included for information only.)

Some Representative Fields of Vision for Selected Viewing Distances Normalized for 2.35, 1.85, and 1.37 Aspect Ratios

Format	θ_H	θ_V	D		Remarks
2.35	37.6	16.1	3.45H	1.46W	Szabo, 1984
1.85	30.0	16.1	3.45H	1.86W	
1.37	22.5	16.1	3.45H	2.50W	
2.35	35.9	15.0	3.73H	1.59W	NIKFI, 1961[9]
1.85	27.8	15.0	3.73H	2.01W	
1.37	20.8	15.0	3.73H	2.72W	
2.35	28.0	12.0	4.70H	2.00W	Meister[2] and
1.85	22.3	12.0	4.70H	3.43W	Philips[10]
1.37	16.5	12.0	4.70H	3.43W	
2.35	26.4	11.3	5.00H	2.12W	Vivié, 1965[11]
1.85	21.0	11.3	5.00H	2.70W	
1.37	15.6	11.3	5.00H	3.65W	
2.35	19.5	8.35	6.81H	2.90W	Soulé, 1980[12]
1.85	15.5	8.35	6.81H	3.70W	
1.37	11.5	8.35	6.81H	5.00W	

Proposed American National Standard

for television analog recording —

½-in type M-2 — records

SMPTE 249M

1. Scope

This standard specifies the dimensions and locations of the video, audio, time code, and tracking-control records, as recorded by ½-in type M-2 helical-scan video tape recorders operating with video signals having a typical scanning structure of 525 lines, 59.94 fields/sec, 2:1 interlace, and utilizing the video cassettes specified in SMPTE 250M. This standard also specifies the records for two different audio recording modes — common audio mode and pulse code modulation (PCM) audio mode.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

SMPTE 250M, Television Analog Recording — ½-in Type M-2 — Tapes and Cassettes

SMPTE 251M, Television Analog Recording — ½-in Type M-2 — Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

SMPTE 252M, Television Analog Recording — ½-in Type M-2 — Pulse Code Modulation Audio

SMPTE RP 158, Basic System and Transport Geometry Parameters for ½-in Type M-2 Format

3. General Specifications

3.1 All dimensions are in the metric system.

3.2 A basic dimension is a fundamental dimension to which no tolerance is applicable.

3.3 Tests and measurements made on the tape record to check the requirements of this standard shall be made under the following conditions unless otherwise specified:

Temperature	20°C ± 1°C
Relative humidity	50% ± 2%
Barometric pressure	86 to 106 kPa
Tape tension	0.31 N ± 0.05 N

3.4 Conditioning of the tape stock before recording and testing shall be as follows:

Environment	Established to the conditions specified in 3.3.
Tape tension	Wound on a reel at a tension of 0.4 N ± 0.1 N.
Condition time	24 hours.

3.5 The reference edge of the tape for dimensions specified in this standard shall be the lower edge as shown in Figs. 1 to 4. The magnetic coating, with the direction of tape travel as shown in Figs. 1 to 4, is on the side facing the observer.

4. Tape Speed

The tape speed shall be 67.693 mm/s, basic.

5. Record Locations and Dimensions

5.1 The locations and dimensions of the video and common audio mode records shall be as specified in Figs. 1 and 2 and Table 1.

5.2 The locations and dimensions of the video and PCM audio mode records shall be as specified in Figs. 3 and 4 and Table 2. The PCM records are recorded by the luminance and chrominance heads and only a single longitudinal audio record shall be available.

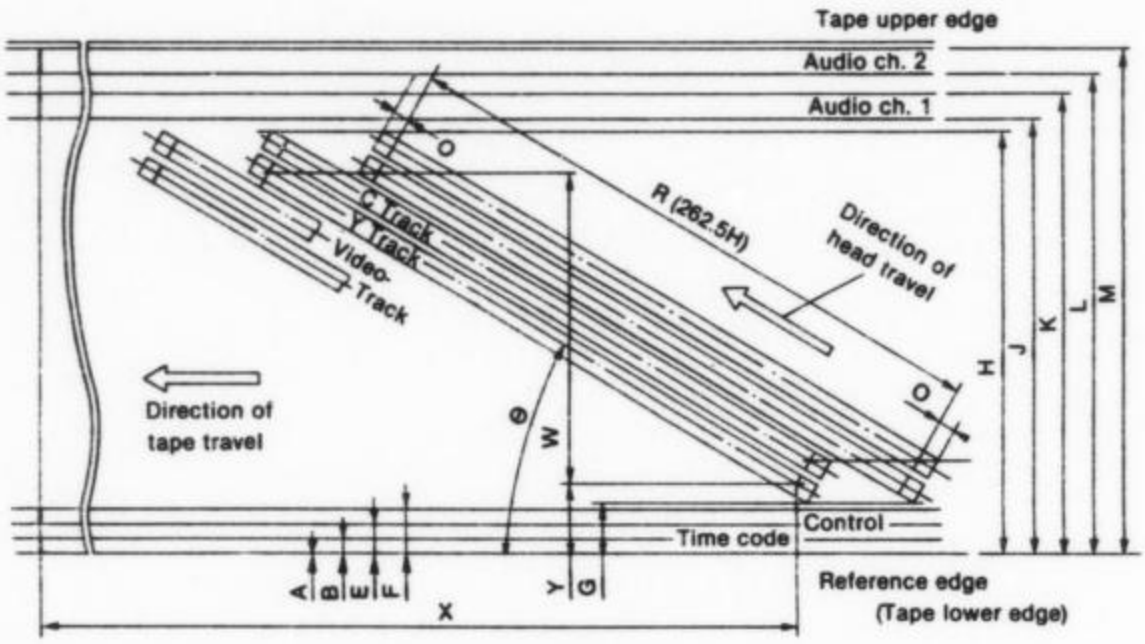


Fig. 1
Record Locations and Dimensions (Common Audio Mode)

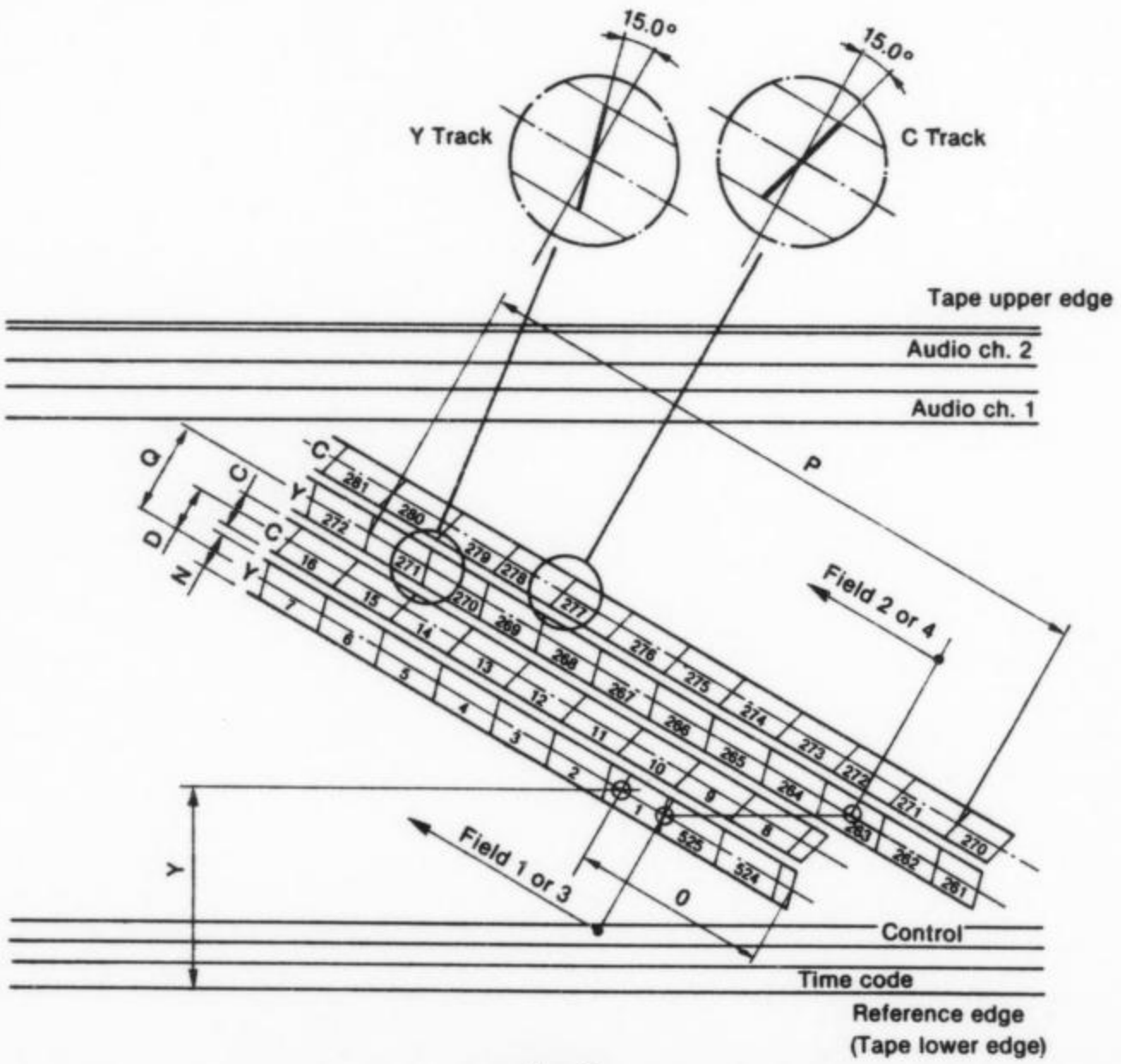


Fig. 2
Video Record Locations (Common Audio Mode)

Table 1
Record Locations and Dimensions (Common Audio Mode)

	Dimensions	Micrometers Minimum	Nominal	Maximum
A	Time code track lower edge	0	0	0
B	Time code track upper edge	400	450	500
C	Color track width	34	36	38
D	Y-C track pitch	40.7	42.2	43.7
E	Control track lower edge	850	900	950
F	Control track upper edge	1250	1300	1350
G	Video track lower edge	1469	1503	1537
H	Video track upper edge	10601	10634	10668
J	Audio 1 track lower edge	10830	10850	10870
K	Audio 1 track upper edge	11400	11450	11500
L	Audio 2 track lower edge	11900	11950	12000
M	Audio 2 track upper edge	12500	12550	12650
N	Y track width	42	44	46
O	Lead signal overlap		3H ref	
P	Y-C track offset		4505 (= 10H) ref	
Q	Video track pitch		84.5 ref	
R	Video track length		118254.3 (262.5H) ref	
W	Video area effective width		8847.1 ref	
X	Audio, time code and control track record offset		202000	
Y	Lower limit of W	1621	1626	1631
θ	Track angle		4.2906° (basic)	

Note: "Ref" indicates those measurements which are fixed by other parameters and are given for reference purposes only.

5.3 Dimensions O, P, Q, R, W, W′, and PE are shown for reference purposes only. The actual value of these dimensions is determined by the tape speed, the transport parameters, and their tolerances.

The tape speed of 67.693 mm/s basic shall result in angle θ as shown. The nominal values given are based on tensioned tape; therefore, direct measurements without tension must take into account tape elasticity.

6. Video Record Curvature

The edge of any video record contained within an area defined by dimension W or the edge of any video and PCM audio record contained within an area defined by dimension W′ shall be contained within two parallel straight lines 0.006 mm apart. (See Appendix.)

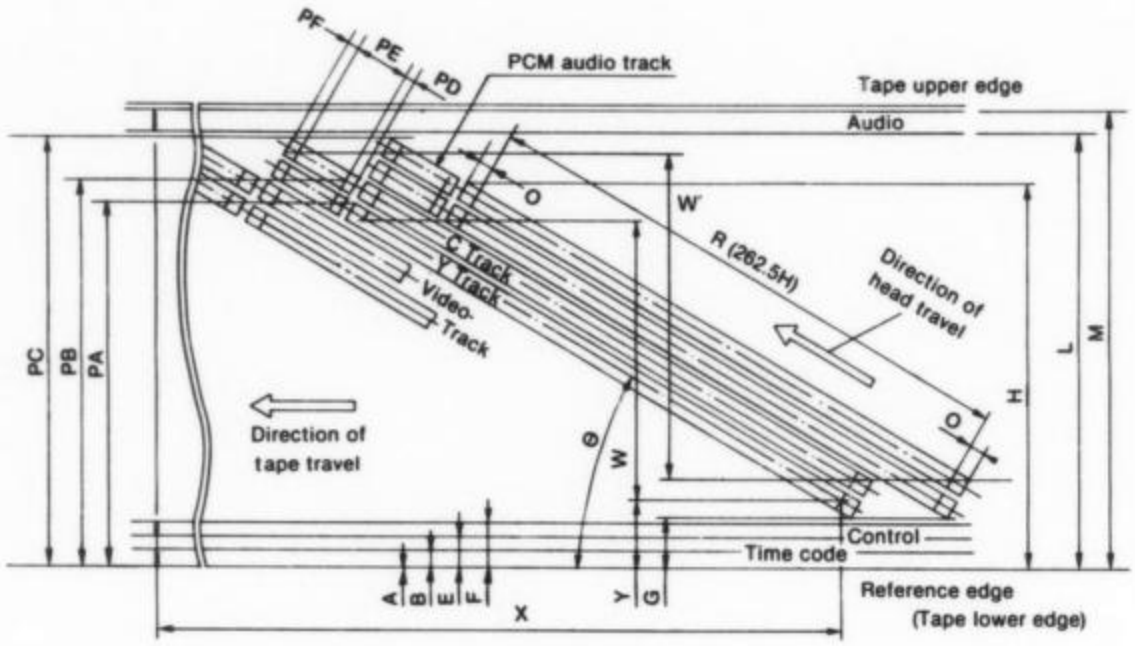


Fig. 3
Record Locations and Dimensions (PCM Audio Mode)

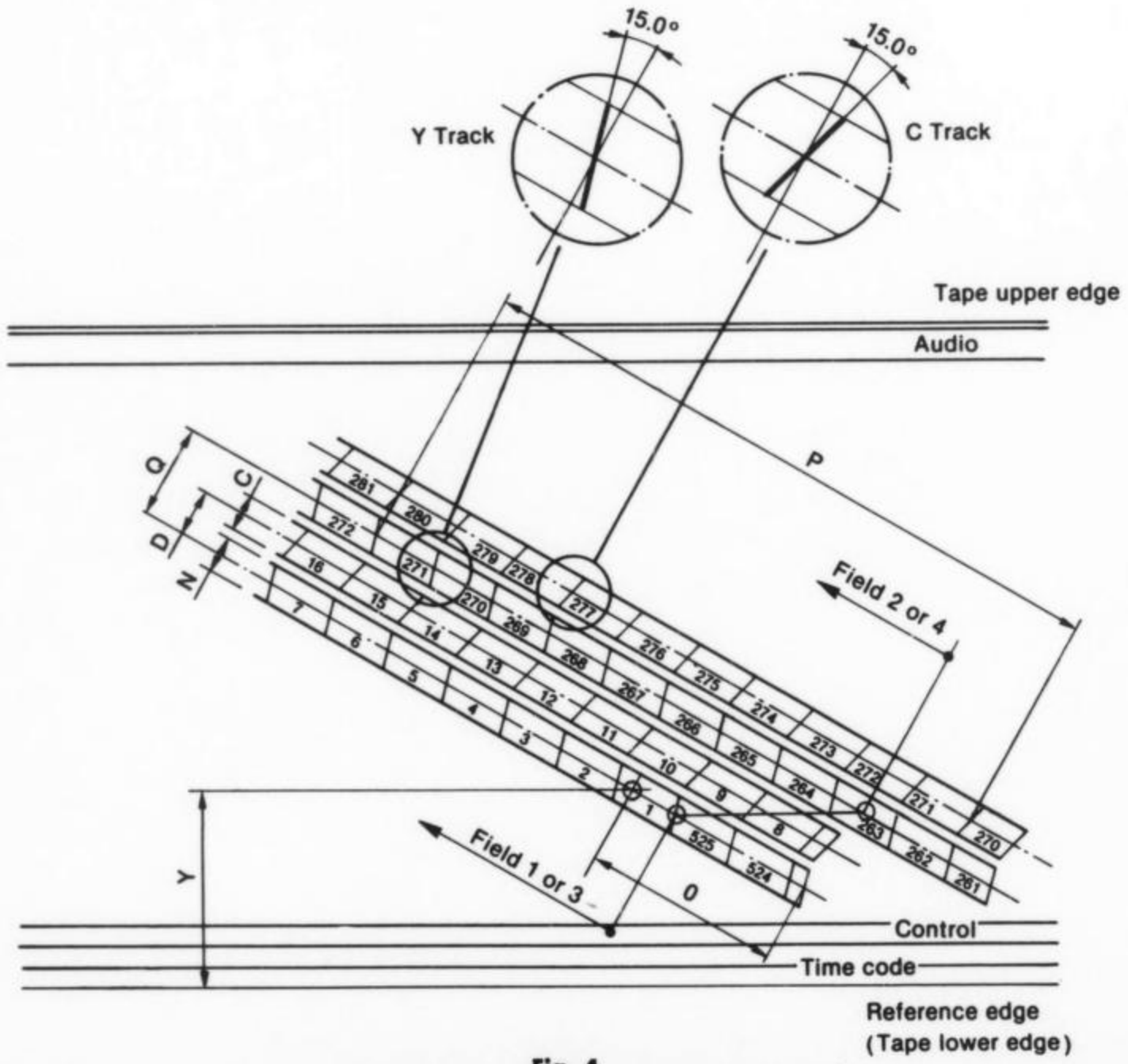


Fig. 4
Video Record Locations (PCM Audio Mode)

Table 2
Record Locations and Dimensions (PCM Audio Mode)

	Dimensions	Micrometers Minimum	Nominal	Maximum
A	Time code track lower edge	0	0	0
B	Time code track upper edge	400	450	500
C	Color track width	34	36	38
D	Y-C track pitch	40.7	42.2	43.7
E	Control track lower edge	850	900	950
F	Control track upper edge	1250	1300	1350
G	Video track lower edge	1469	1503	1537
H	Video track upper edge	10601	10634	10668
L	Audio track lower edge	11900	11950	12000
M	Audio track upper edge	12500	12550	12650
N	Y track width	42	44	46
O	Lead signal overlap		3H ref	
P	Y-C track offset		4505 (= 10H) ref	
Q	Video track pitch		84.5 ref	
R	Video track length		118254.3 (262.5H) ref	
W	Video area effective width		8847.1 ref	
W′	Video and PCM audio (CH6) area effective width		9973.5 ref	
X	Audio, time code and control track record offset		202000	
Y	Lower limit of W	1621	1626	1631
θ	Track angle		4.2906° (basic)	
PA	Effective PCM audio track lower edge (luminance head)	10676	10709	10743
PB	Effective PCM audio track lower edge (chrominance head)	10724	10758	10791
PC	PCM audio track upper edge (chrominance head)	11660	11693	11727
PD	Preamble	360	450	541
PE	PCM audio data area		11820 ref	
PF	Postamble	360	450	541

Note: "Ref" indicates those measurements which are fixed by other parameters and are given for reference purposes only.

7. Relative Positions of Signal Records

Video luminance, color difference, tracking-control, longitudinal audio, and time-code signals, with information intended to be time coincident, shall be positioned as shown in Figs. 1 to 4. PCM audio shall be positioned as shown in Figs. 3 and 4.

8. Gap Azimuth

8.1 The azimuth of the audio, tracking-control, and time code head gaps used to produce longitudinal track records shall be perpendicular to the direction of relative head-to-tape motion. (See Figs. 1 and 3.)

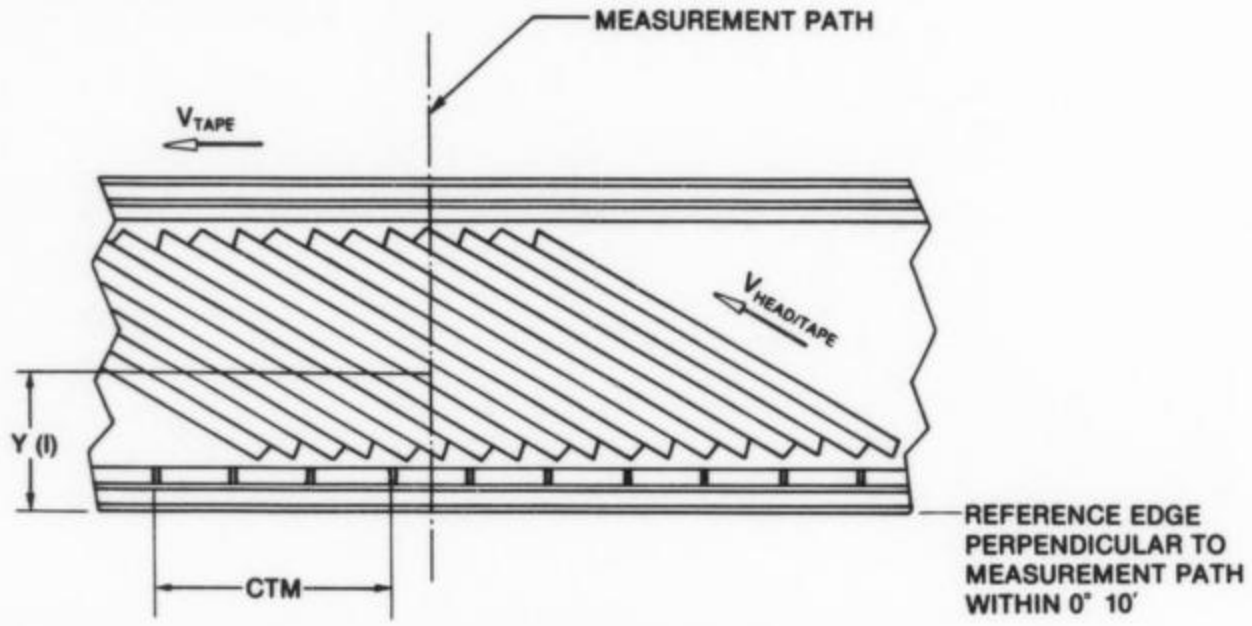
8.2 The azimuth of the video head gaps for the luminance signal shall be — 15.0° and for the color difference signals shall be + 15.0° to the perpendicular of the direction of head motion. (See Figs. 2 and 4.)

Appendix

(This Appendix is not part of the American National Standard, but is included for information only.)

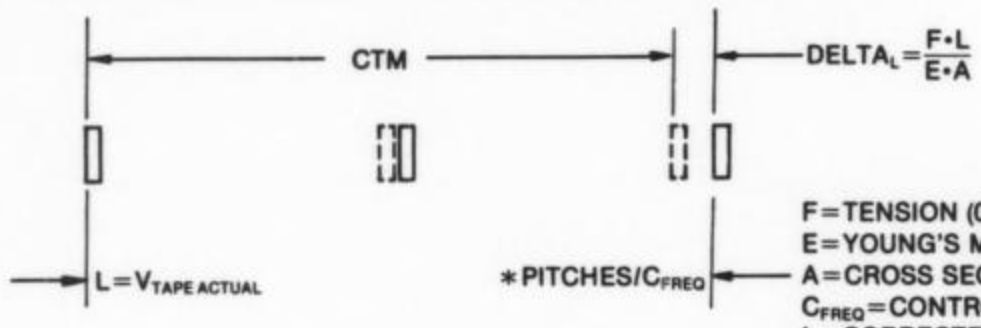
CROSS TAPE TRACK MEASUREMENT TECHNIQUE (PREFERRED)

MEASUREMENT TECHNIQUE



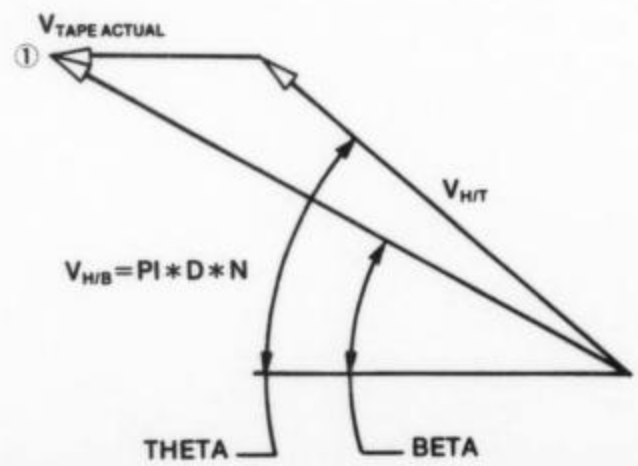
Y (I) MUST USE SAME HEAD FOR EACH MEASUREMENT (i.e. EVERY 2nd TRACK)
CTM = CONTROL TRACK PULSES (UNTENSIONED TAPE)

CORRECTION FACTORS ACTUAL TAPE SPEED, TENSION


CTM
$DELTA_L = \frac{F \cdot L}{E \cdot A}$
$L = V_{TAPE\ ACTUAL}$
$* PITCHES/C_{FREQ}$
F = TENSION (0.31 N)
E = YOUNG'S MODULUS (8000 N/mm²)
A = CROSS SECTIONAL AREA (THICKNESS × WIDTH)
C_{FREQ} = CONTROL TRACK FREQUENCY (59.94 Hz)
L = CORRECTED DISTANCE

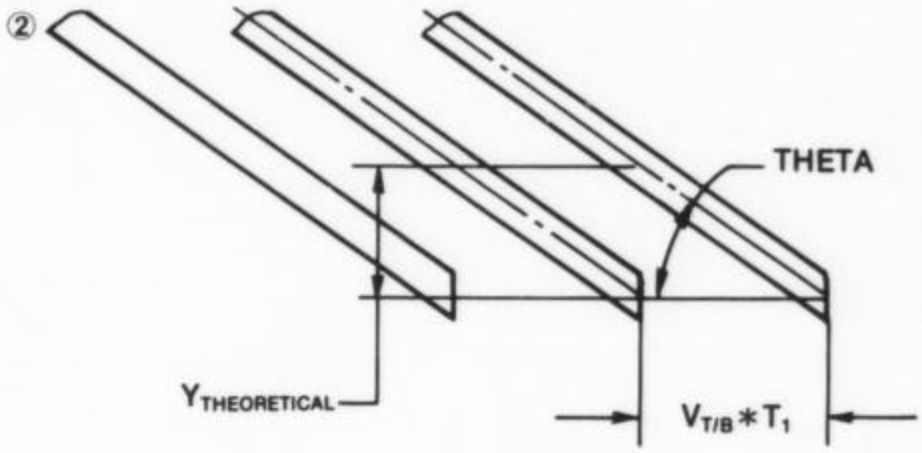
$$V_{TAPE\ ACTUAL} = CTM * C_{FREQ} / ((1 - F/(E * A)) * PITCHES)$$

MODEL



$V_{H/B}$ = VELOCITY OF HEAD wrt BAND
$V_{TAPE\ ACTUAL}$ = ACTUAL VELOCITY of TAPE
$V_{H/T}$ = VELOCITY of HEAD wrt TAPE
D = EFFECTIVE SCANNER DIAMETER
N = SCANNER SPEED $(\frac{REV}{S})$
THETA = TRACK ANGLE
BETA = SCANNER HELIX ANGLE

②



T_1 = TIME BETWEEN HEAD PASSES

$$= \frac{1}{N * HPPR}$$

HPPR = HEAD PASSES per REVOLUTION

FROM ①

$$TAN\ (THETA) = \frac{PI * D * N * SIN\ (BETA)}{PI * D * N * COS\ (BETA) - V_{TAPE\ ACTUAL}}$$

FROM ②

$$TAN\ (THETA) = \frac{Y_{THEORETICAL}}{V_{TAPE\ ACTUAL} * T_1}$$

THEREFORE:

$$Y_{THEORETICAL} = \frac{PI * D * N * SIN\ (BETA)}{PI * D * N * COS\ (BETA) - V_{TAPE\ ACTUAL}} * V_{TAPE\ ACTUAL} * T_1$$

$$TRACK\ LOCATION\ ERROR = Y\ (I) - Y\ (I)_{THEORETICAL}$$

Proposed American National Standard

for television analog recording—

½-in type M-2—
tapes and cassettes

SMPTE 250M

1. Scope

This standard specifies tapes and cassettes for the ½-in type M-2 helical-scan video tape recording system.

2. General Specifications

2.1 Dimensions are in the metric system.

2.2 Tests and measurements for confirming the requirements of this standard shall be made under the following conditions unless otherwise specified:

Temperature	20°C ± 1°C
Relative humidity	50% ± 2%
Barometric pressure	86 to 106 kPa

2.3 Specimens shall be stored under the test conditions specified in 2.2 for 24 hours prior to the test.

3. Cassette Type

There are two cassette types which are identified by outside dimensions shown below:

Large cassette (L)	106 x 188 x 25 mm
Small cassette (S)	87 x 130 x 25 mm

4. Video Tape

The video tape shall have the following characteristics:

4.1	Type of video tape	Metal particle
4.2	Base material	Polyethylene terephthalate or its equivalent
4.3	Direction of particle orientation	Longitudinal direction of tape
4.4	Coercivity	Class 1500
4.5	Light transmissivity	5% or less (measured over the range of wavelengths 700 to 900 nm)
4.6	Total thickness	13.5 μm ± 0.5 μm
4.7	Width	12.65 mm ± 0.01 mm
4.8	Width fluctuation	6 μm or less

5. Leader Tape and Trailer Tape

The leader tape and trailer tape shall have the following characteristics:

5.1	Light transmissivity	50% or more (measured over the range of wavelengths 700 to 900 nm)
5.2	Length	for large cassette 170 mm ± 15 mm for small cassette 140 mm ± 10 mm

Length of the leader and trailer tape is defined between the end of the leader or trailer tape to a point where this tape is attached by a splicing tape to the metal particle tape.

5.3	Tape thickness	13 to 36 μm
5.4	Width	12.65 mm ± 0.02 mm
5.5	Splicing tape length	13 to 20 mm
5.6	Splicing tape thickness	25 μm or less
5.7	Splicing strength to reel hub	20 N or more
5.8	Splicing strength to video tape	20 N or more

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5.9 Breaking strength of leader tape — 30 N or more

5.10 Offset yield strength of leader tape — 18 N or more

6. Video Tape Length and Record/Playback Time

Tape length and record/playback time specifications shall be as given in Tables 1 and 2.

Table 1
Definition of Play/Record Time for Large Cassette

Record/Play Time (min)	Tape Length (m)
95	389^{+3}_{0}
65	267^{+3}_{0}
35	145^{+3}_{0}
23	96^{+3}_{0}
12	51^{+3}_{0}

Table 2
Definition of Play/Record Time for Small Cassette

Record/Play Time (min)	Tape Length (m)
23	96^{+3}_{0}
12	51^{+3}_{0}

7. Video Cassette

The video cassette shall be specified by the following descriptions:

7.1 Cassette Dimensions. Large cassettes shall conform to Figs. 1 to 8. Small cassettes shall conform to Figs. 9 to 20.

7.2 Cassette Datum System

7.2.1 Datum Holes. Datum holes shall be holes serving as a reference when loading a cassette in the video tape recorder, and shall also be the datum reference of the cassette dimensions. (See Figs. 2 to 4 and 10 to 12.)

7.2.2 Datum Plane Z. Datum plane Z shall be a plane containing three datum places, A, B, and C, on the cassette bottom. (See Figs. 4 and 12.)

7.2.3 Datum Plane X

7.2.3.1 Large Cassette. This plane shall be orthogonal to datum plane Z containing the centerlines of datum holes A and B. (See Figs. 2 to 4.)

7.2.3.2 Small Cassette. This plane shall be parallel to the long side face of the cassette and shall be orthogonal to datum plane Z, containing the centerline of datum hole A. (See Figs. 10 to 12.)

7.2.4 Datum Plane Y. Datum plane Y shall be a plane orthogonal to both datum planes Z and X, containing the centerline of datum hole A. (See Figs. 2 to 4 and 10 to 12.)

7.3 Window and Label Pasting Face. Large cassettes shall conform to Fig. 1 and small cassettes to Fig. 9.

7.4 Identification Holes. Multiple holes shall be provided for identifying the conditions of the cassette. (See Figs. 2 and 10.) Each hole may be set in a closed state or an opened state:

Closed state	The hole depth shall be 0 to 0.25 mm and shall withstand a force of 0.5 N.
Opened state	The hole diameter shall be 3 mm + 0.3 mm — 0.1 mm. The hole depth shall be 5 mm or more.

7.4.1 Record Lock-Out Identification Hole. Large cassettes shall be as specified in Fig. 2 and small cassettes as in Fig. 10.

The record lock-out identification hole shall be coupled to the record lock-out mechanism shown in Figs. 1 and 9, and may be changed between the closed state and the opened state. Each state shall be defined as follows:

Identification hole closed	Ready to record
Identification hole opened	Record lock out

7.4.2 Tape Type Identification Hole. Large cassettes shall be as specified in Fig. 2 and small cassettes as in Fig. 10.

The closed or opened state of the identification hole shall be defined as follows:

Identification hole closed	Metal particle tape (Coercivity class 1500)
Identification hole opened	Reserved

7.4.3 Tape Thickness Identification Hole. Large cassettes shall be as specified in Fig. 2 and small cassettes as in Fig. 10.

The closed or opened state of the identification hole shall be defined as follows:

Identification hole closed	Tape total thickness is 13.5 μm $\pm$ 0.5 μm
Identification hole opened	Reserved

7.4.4 Additional Identification Holes. These holes are provided for future usage. The positions of these reserved holes shall be as follows: Large cassettes shall be as specified in Fig. 2 (five holes) and small cassettes shall be as specified in Fig. 10 (two holes).

7.5 Dimensions of the reel shall conform to Figs. 6, 14, and 15.

7.6 The tape winding method and path shall conform to Figs. 7 and 16.

7.7 The E value shall be 1.0 mm or more. (See Note 4 of Fig. 5 and Note 5 of Fig. 13.)

7.8 The structure of the lid shall conform to Figs. 8 and 17. The lid shall be unlocked when a force of not more than 0.15 N for large cassettes or a force of not more than 0.30 N for small cassettes is applied to the unlocking clutch as shown in Note 8 of Fig. 1, Note 6 of Fig. 9, and Fig. 19.

7.9 The force necessary for opening the lid shown in Note 7 of Fig. 3 and Fig. 17 shall be 1 N or less.

7.10 The reel brakes shall be released by a force of not more than 0.7 N by means of a reel brake unlocking pin as shown in Note 4 of Fig. 3 and Note 3 of Fig. 11.

7.11 The cassette reels shall be pushed down by a reel spring with a force of 2.0 N $\pm$ 0.3 N for large cassettes and 1.5 N $\pm$ 0.3 N for small cassettes, as shown in Fig. 5b and Fig. 13b.

7.12 The minimum space required for the recorder and/or player loading mechanism shall be as shown in Fig. 18.

7.13 Screw Positions. Screw positions for assembling the upper and lower cassette halves should be as shown in Fig. 8 (large cassette) and Fig. 20 (small cassette). The diameter of the spot facing for the screw head should be within 3.8 to 6.2 mm. The diameter of the spot facing for the screw head described in Note 1 of Fig. 20 shall be 5.3 to 5.7 mm. No screw head shall protrude beyond the cassette surface.

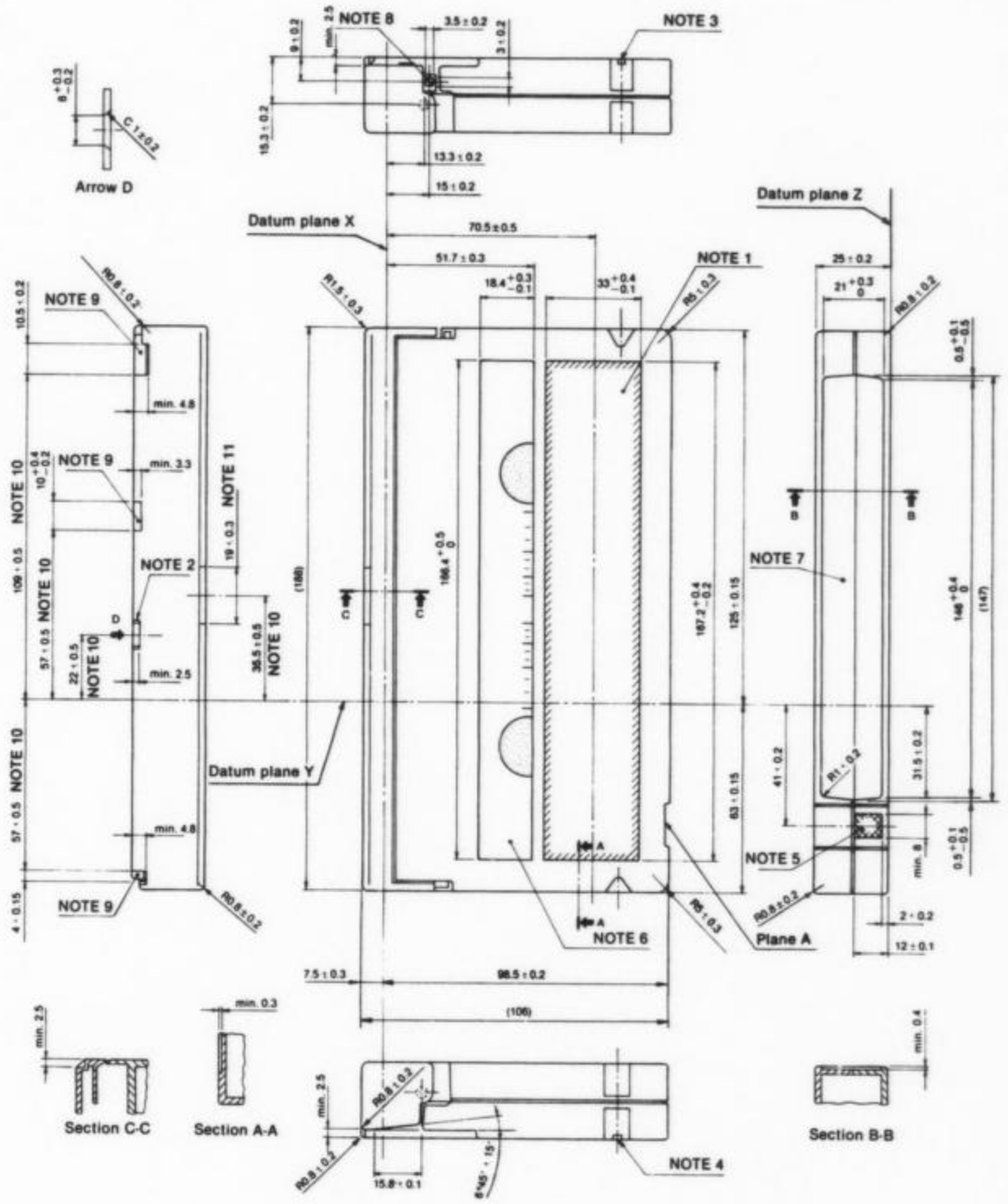


Fig. 1
Top and Side Views of Large Cassette

Notes:
1. Top Label Pasting Face. The label shall not protrude beyond the cassette height.
2. Guide groove A to prevent misinsertion. (Dimension at the lid is shown.)
3. Guide groove B to prevent misinsertion.
4. Guide groove C to prevent misinsertion.
5. Operation of Record Lock-Out Hole. When the record lock-out hole is open, recording should be impossible. The minimum hole depth is 2.9 mm from plane A. When the hole is closed, recording should be possible. The record lock-out mechanism shall be coupled with the identification hole shown in Note 9 of Fig. 2.
6. Window. This window shall not protrude beyond the cassette height.
7. Side Label Face. The label shall not protrude beyond the cassette side.
8. Lid unlocking clutch.
9. Cassette front positioning face.
10. These tolerances include a slight play of the lid.
11. Recess to prevent misinsertion.

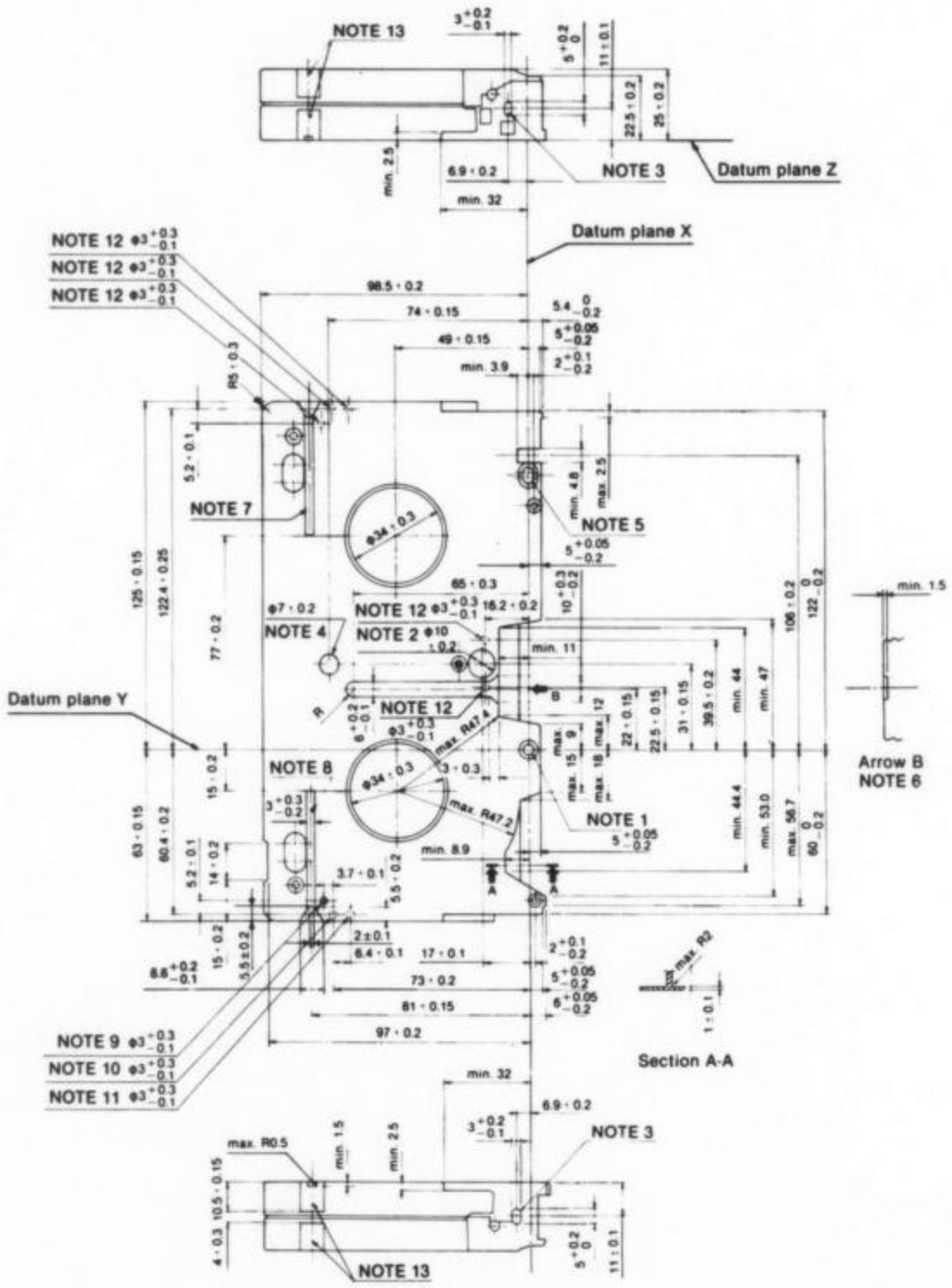


Fig. 2
Bottom View of Large Cassette

Notes:
1. Datum hole A.
2. Hole for the sensor lamp.
3. Holes for the sensor optical path.
4. Reel brake unlocking hole.
5. Datum hole B.
6. Guide groove A to prevent misinsertion.
7. Guide groove B to prevent misinsertion.
8. Guide groove C to prevent misinsertion.
9. Record lock-out identification hole.
10. Tape type identification hole.
11. Tape thickness identification hole.
12. Extra identification holes (five holes).
13. Grip for automatic loading machine

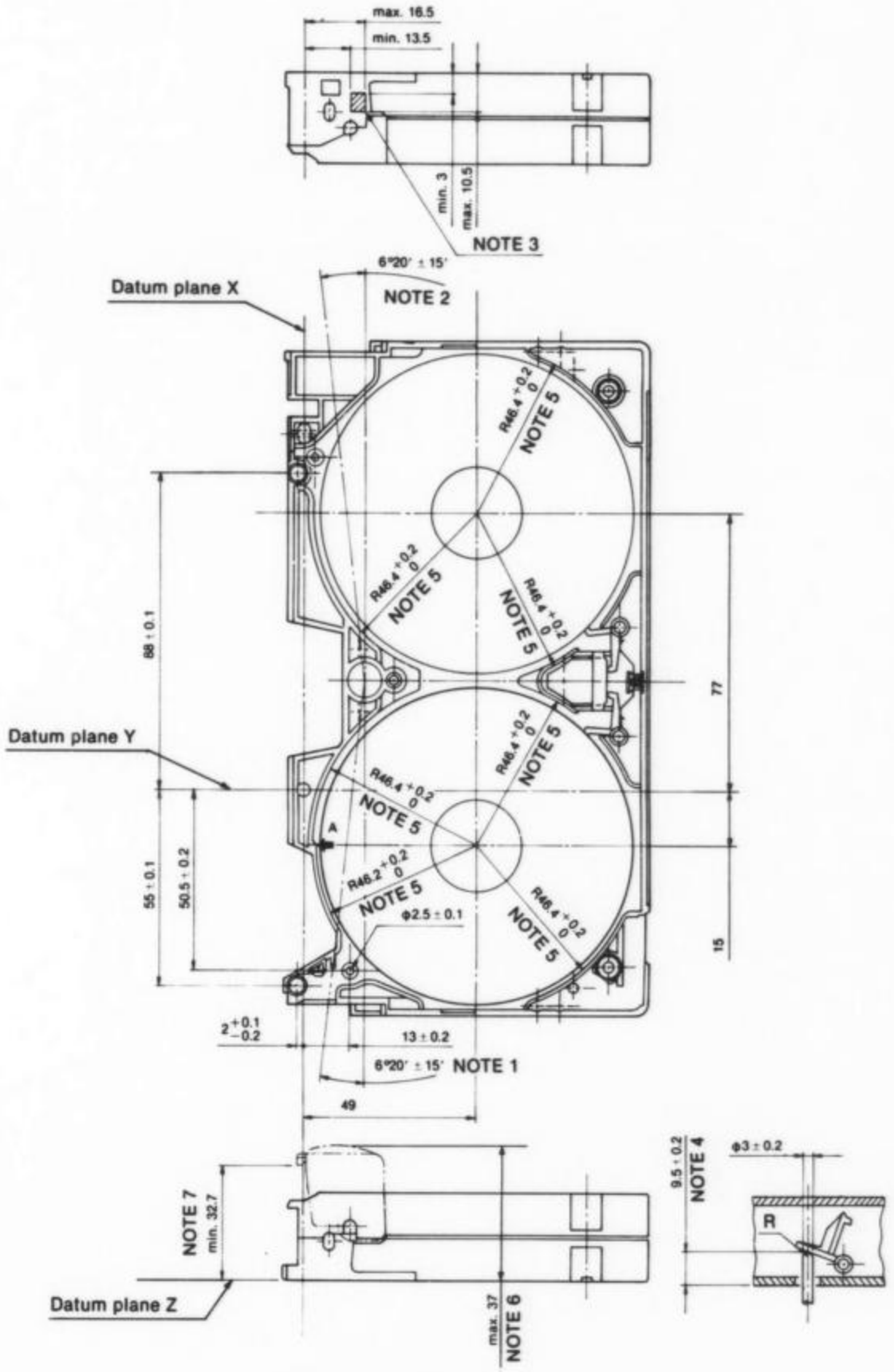
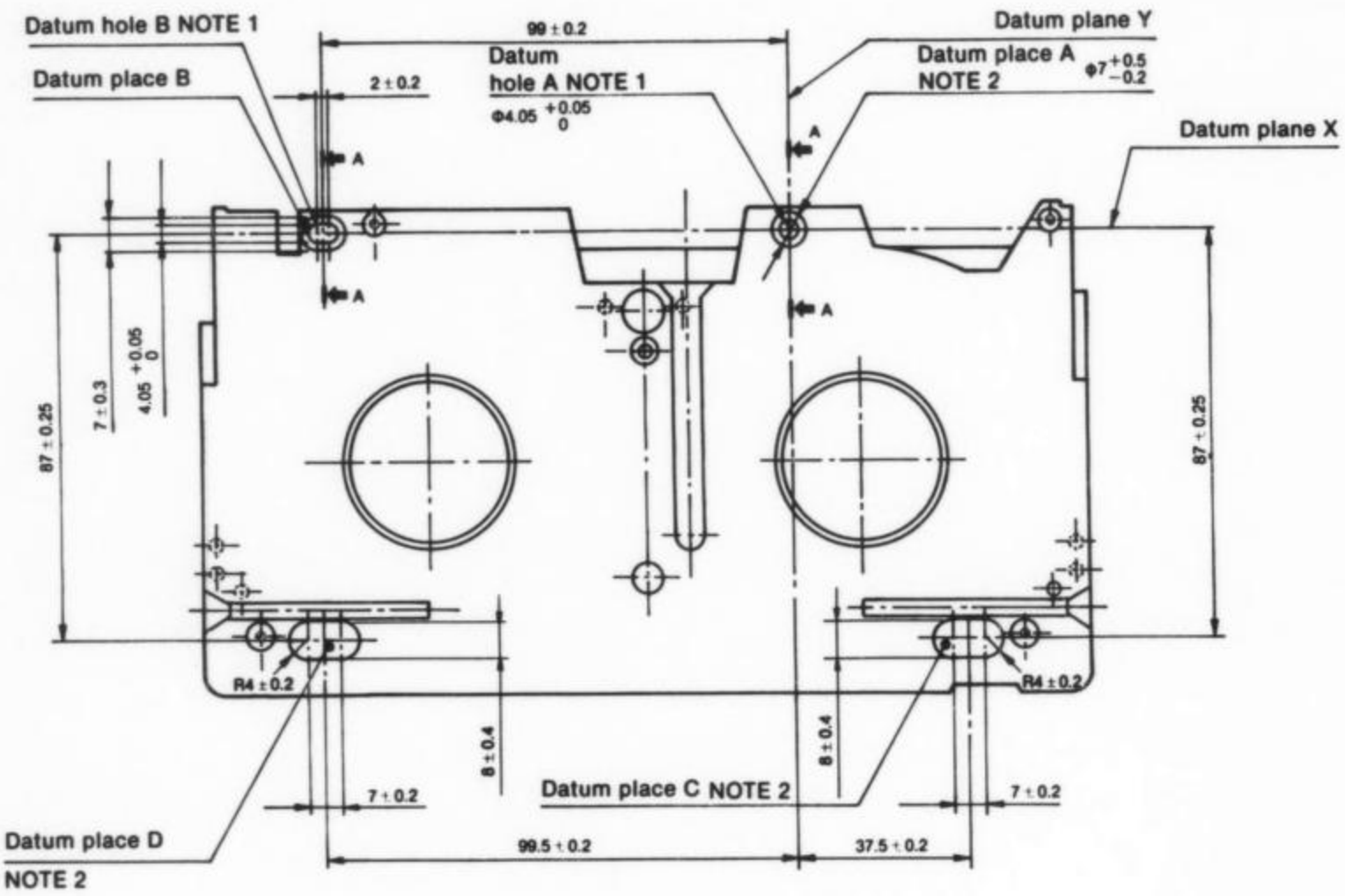


Fig. 3
Inner Structure of Large Cassette

Notes:
1. Supply side sensor optical path angle.
2. Take-up side sensor optical path angle.
3. Pushing position of the lid unlocking device.
4. Position of the brake unlocking pin of the recorder.
5. The space of this dimension shall be maintained throughout the entire circumference of the inner wall.
6. Maximum permissible height when the lid is opened.
7. The lid minimum opening dimension. This dimension shall be applied over the cassette front tape threading range. (See Fig. 7 for tape threading path.)



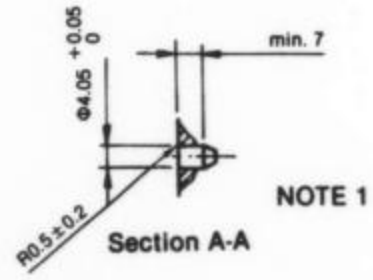
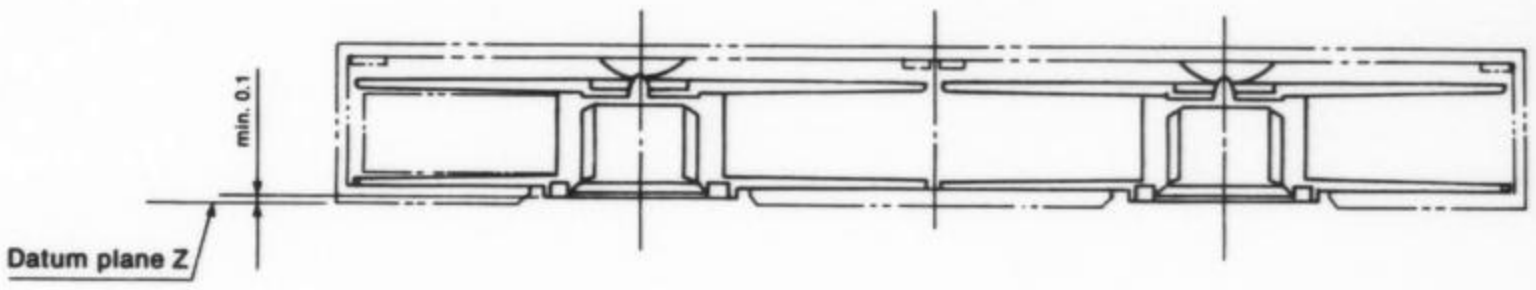


Fig. 4
Datum Places and Support Surfaces of Large Cassette

Notes: 1. The diameter of the datum hole in Section A-A shall be 4.05 mm + 0.05 mm — 0.00 mm and 7 mm in depth.

2. The flatness of the four datum places shall be 0.2 mm or less. The datum places are used as the supporting surfaces of the cassette.

(a) Condition off the machine



(b) Condition loaded on the machine

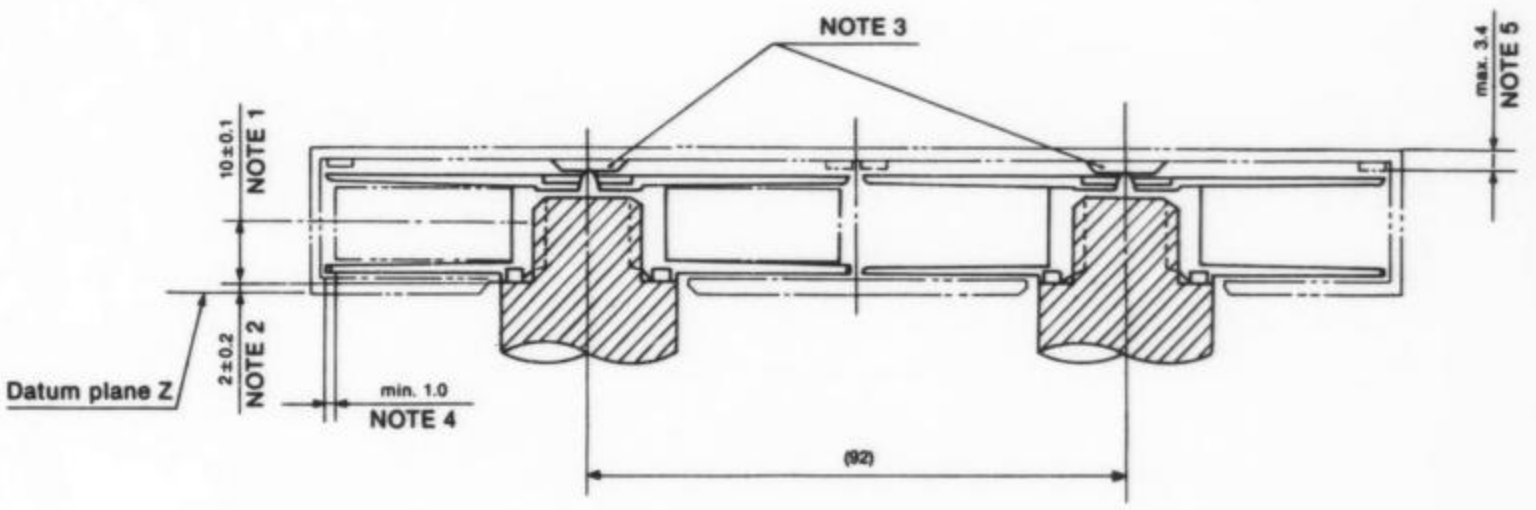


Fig. 5
Relationship Between Reels and Reel Stands for Large Cassette

Notes:
1. Centerline of tape.
2. Height of reel stand above cassette datum plane Z. The cassette tape reel shall be smoothly operated at a height of 2.0 mm ± 0.2 mm.
3. Reel springs.
4. E value (a margin between reel flange outside diameter and maximum wound tape diameter).
5. Reel stoppers to limit the play of the reel.

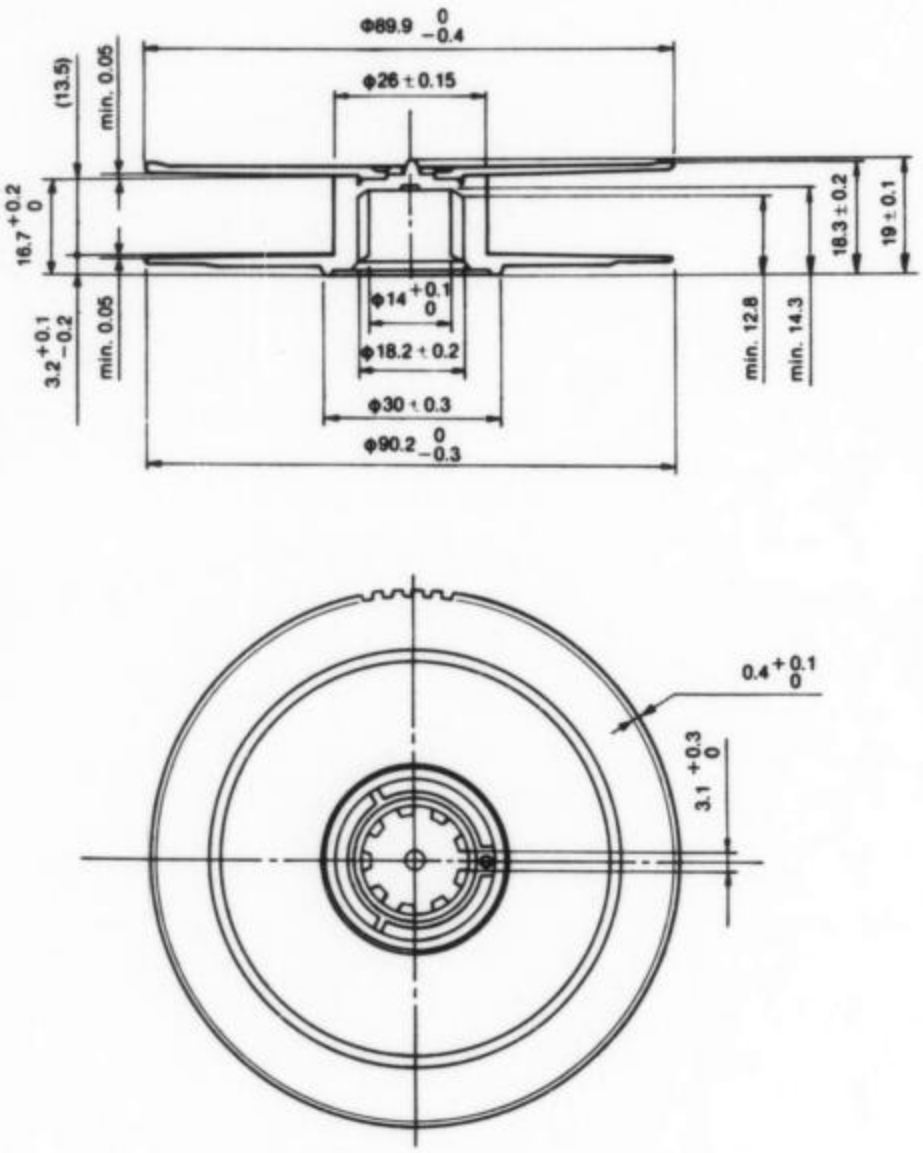


Fig. 6
Reel Dimensions of Large Cassette

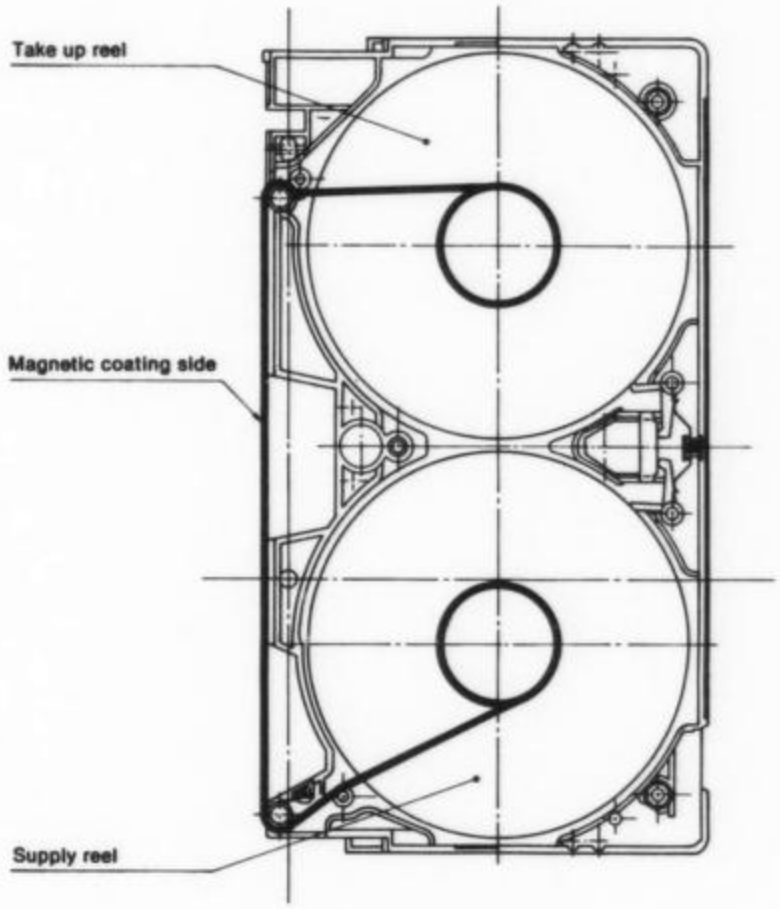


Fig. 7
Tape Path in Large Cassette

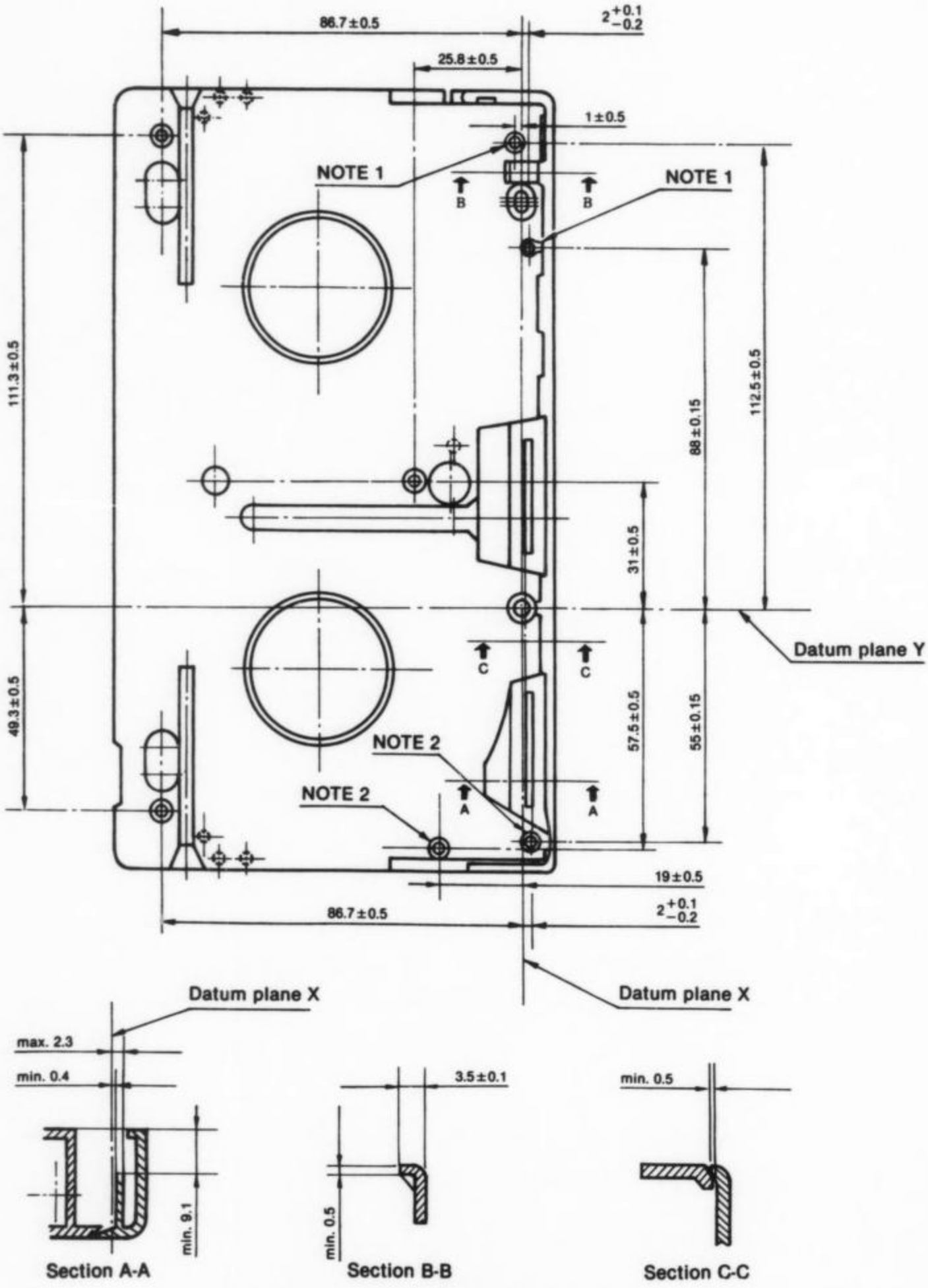


Fig. 8
Screw Positions and Lid Structure of Large Cassette

Notes: 1. Either one of two screw positions may be used.
2. Either one of two screw positions may be used.

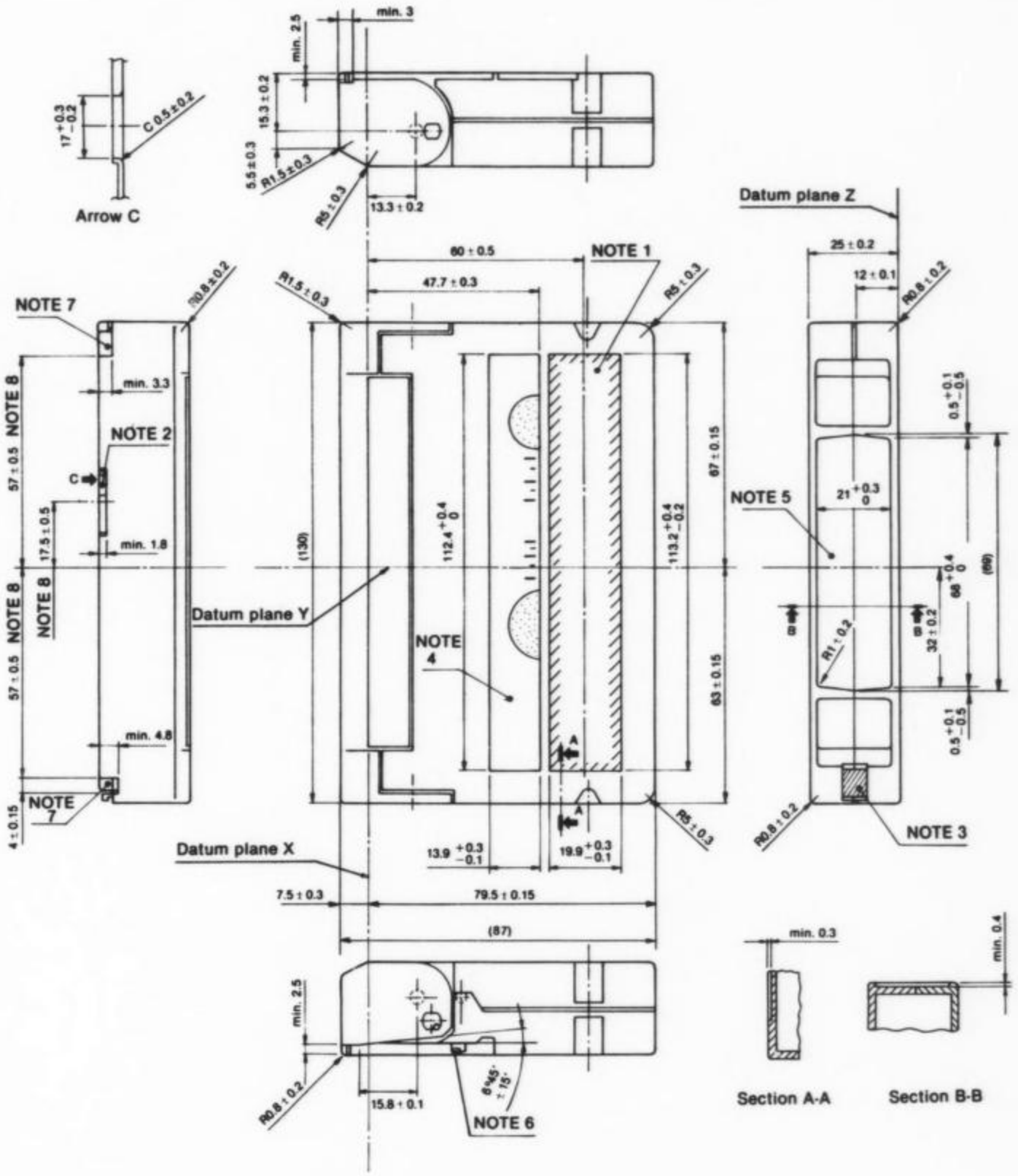


Fig. 9
Top and Side Views of Small Cassette

Notes:
1. Top Label Pasting Face. The label shall not protrude beyond the cassette height.
2. Guide groove to prevent misinsertion.
3. Operation of Record Lock-Out Hole. When the record lock-out hole is open, recording should be impossible. When the hole is closed, recording should be possible. The record lock-out mechanism shall be coupled with the identification hole shown in Fig. 10 (Note 6).
4. Window. This window shall not protrude beyond the cassette height.
5. Side Label Pasting Face. The label shall not protrude beyond the cassette side.
6. Lid unlocking clutch.
7. Cassette front positioning face.
8. These tolerances include a slight play of the lid.

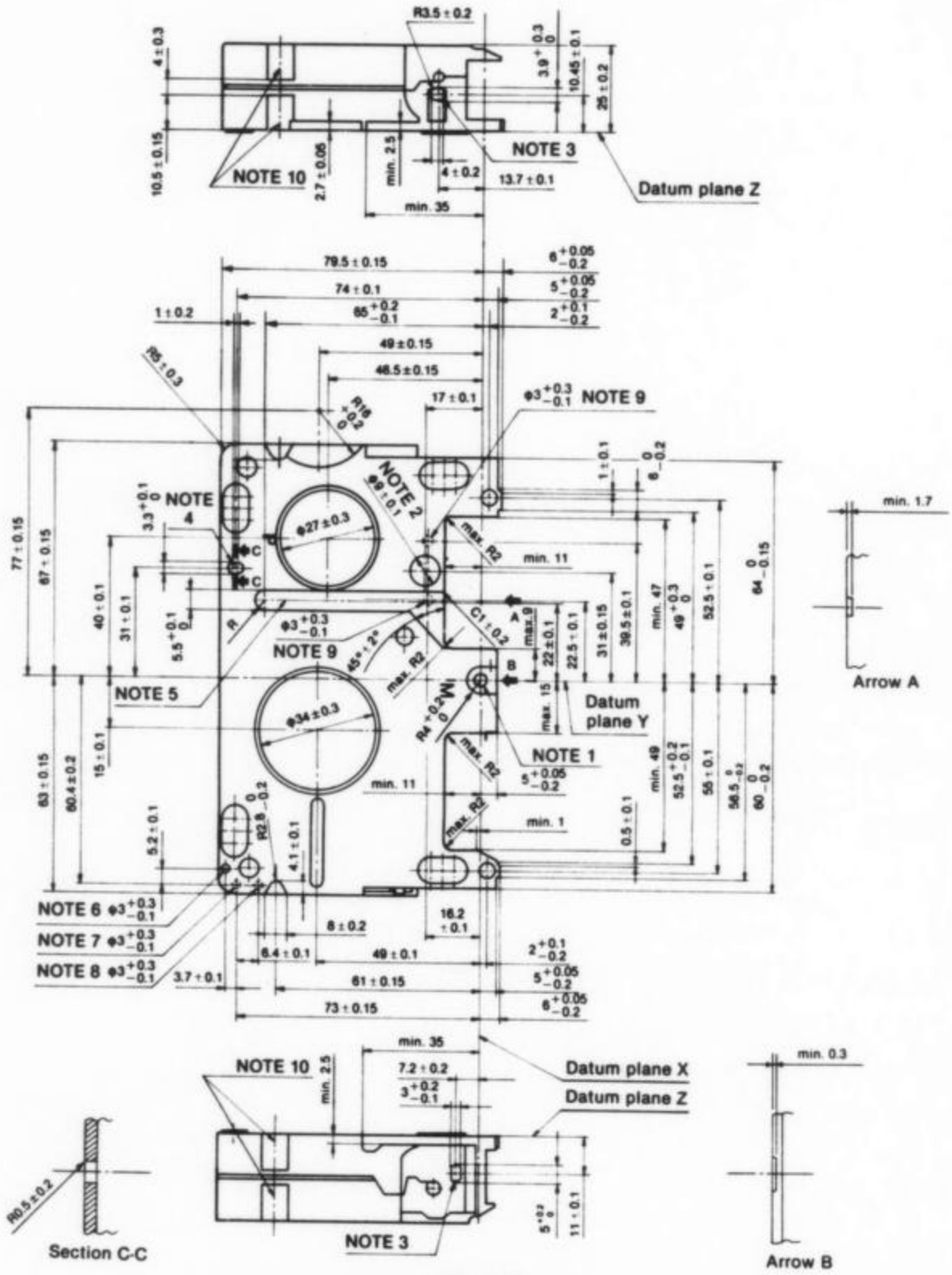


Fig. 10
Bottom View of Small Cassette

Notes:
1. Datum hole.
2. Hole for sensor lamp.
3. Holes for sensor optical path.
4. Reel brake unlocking hole.
5. Guide groove to prevent misinsertion.
6. Record lock-out identification hole.
7. Tape type identification hole.
8. Tape thickness identification hole.
9. Extra identification holes (two holes).
10. Grip for automatic loading machine.

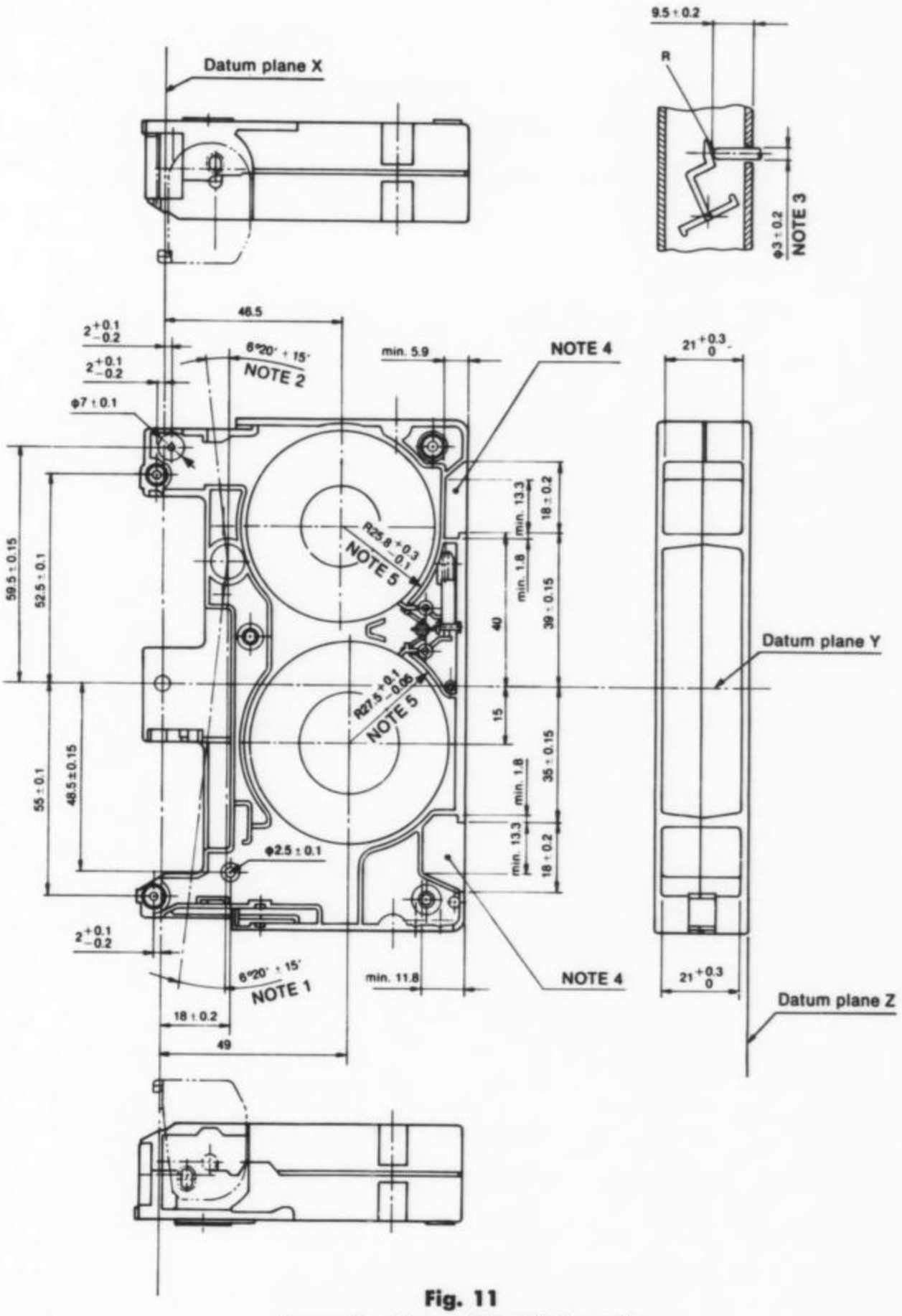


Fig. 11
Inner Structure of Small Cassette

Notes:
1. Supply side sensor optical path angle.
2. Take-up side sensor optical path angle.
3. Position of the brake unlocking pin of the recorder.
4. Finger hole.
5. This dimension shall be maintained throughout the entire circumference of the inner wall.

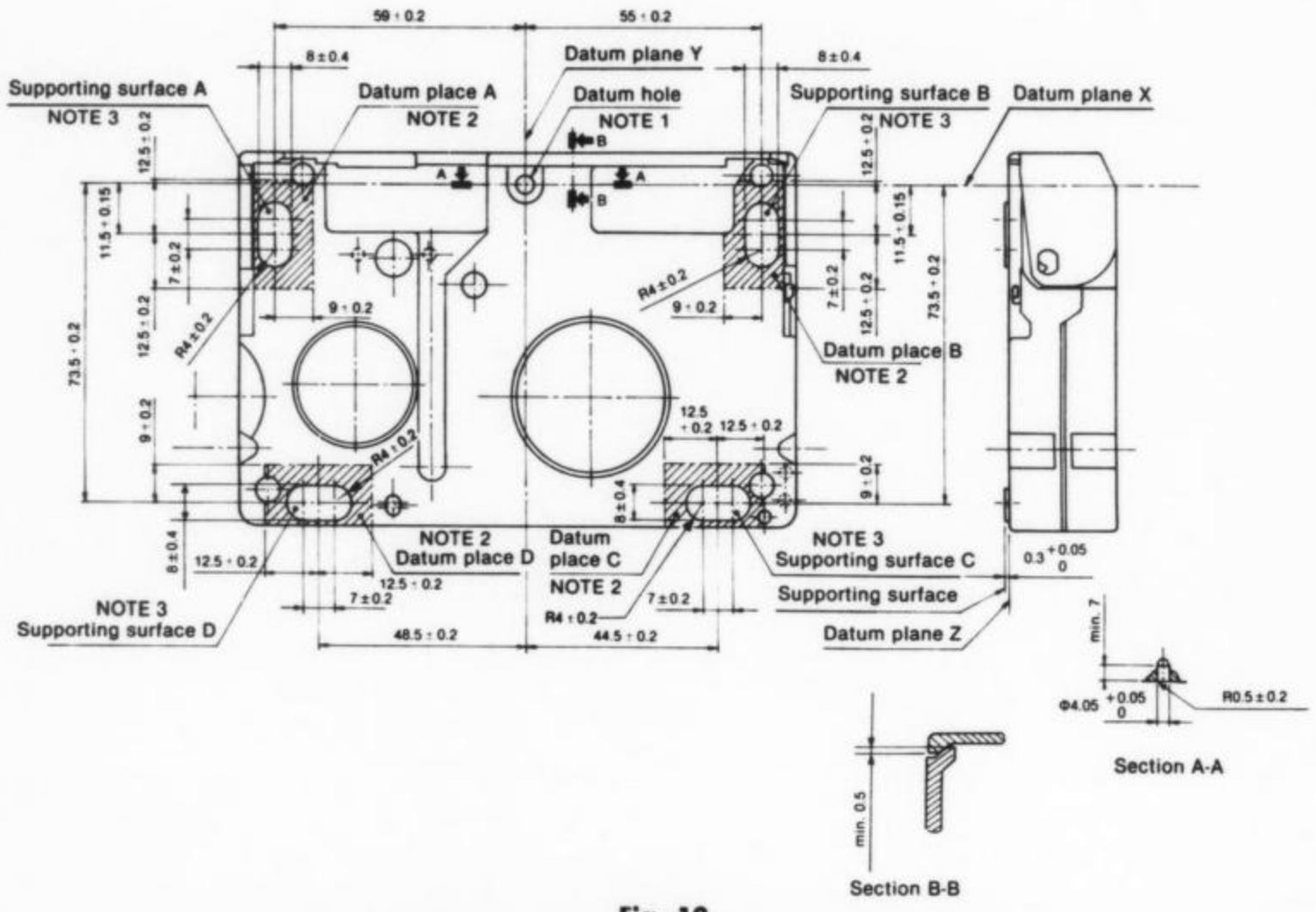
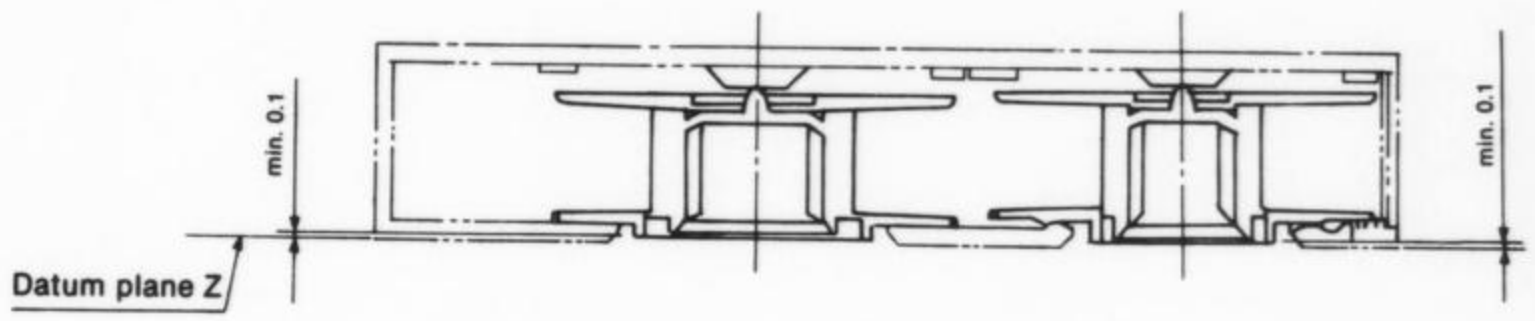


Fig. 12
Datum Places and Supporting Surfaces of Small Cassette

Notes:
1. The diameter of the datum hole in Section A-A shall be 4.05 mm + 0.05 mm — 0.00 mm and 7 mm in depth.
2. The flatness of the four datum places shall be 0.2 mm or less.
3. The flatness of the four supporting surfaces shall be 0.2 mm or less. The supporting surfaces are used as the cassette supporting surfaces for cassette loading.

(a) Condition off the machine



(b) Condition loaded on the machine

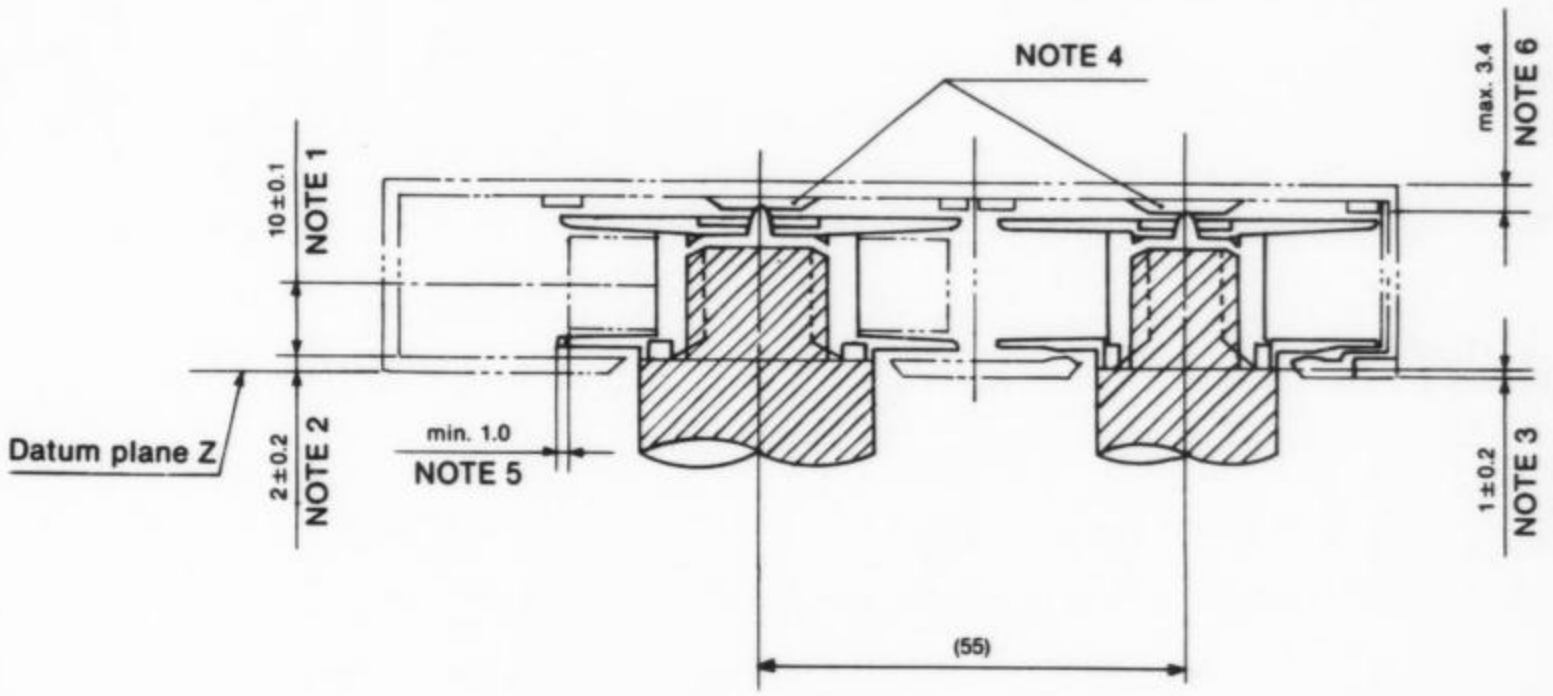
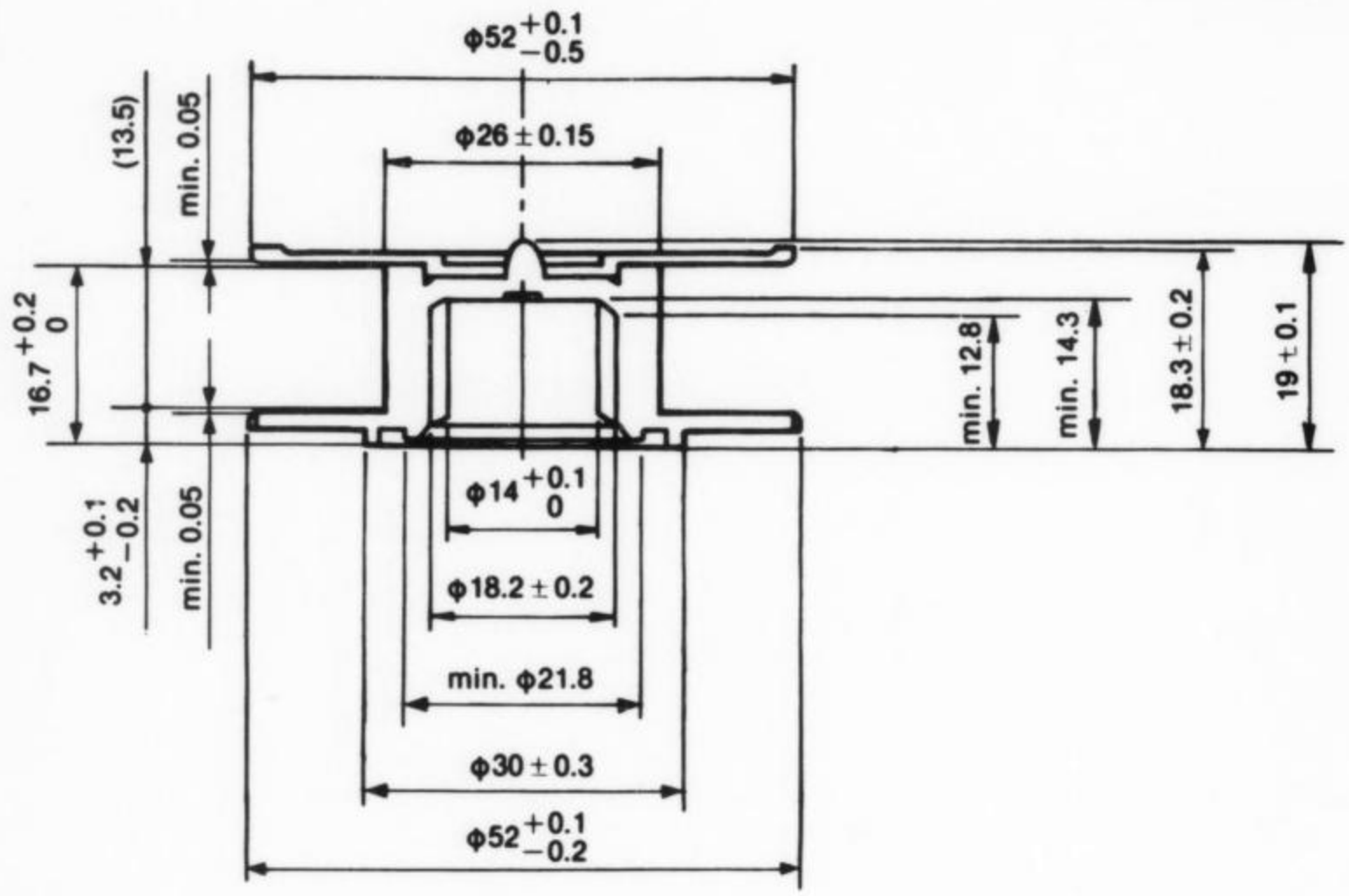


Fig. 13
Relationship Between Reels and Reel Stands of Small Cassette

Notes:
1. Centerline of tape.
2. Height of supply reel stand above cassette datum plane Z. The cassette shall operate smoothly at a height of 2.0 mm ± 0.2 mm.
3. Height of take-up reel stand above cassette datum plane Z. The cassette shall operate smoothly at a height of 1.0 mm ± 0.2 mm.
4. Reel springs.
5. E value (a margin between reel flange outside diameter and maximum wound tape diameter).
6. Reel stoppers to limit the play of the reel.



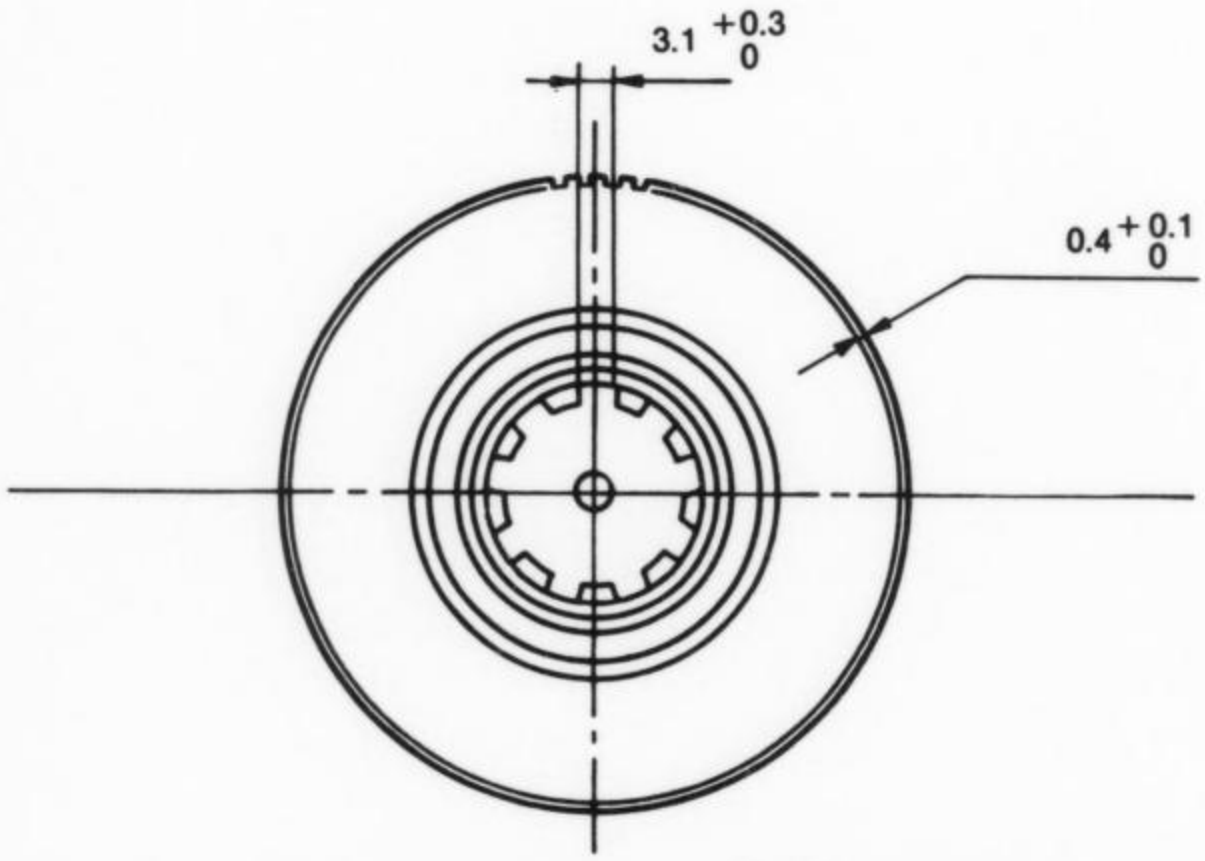
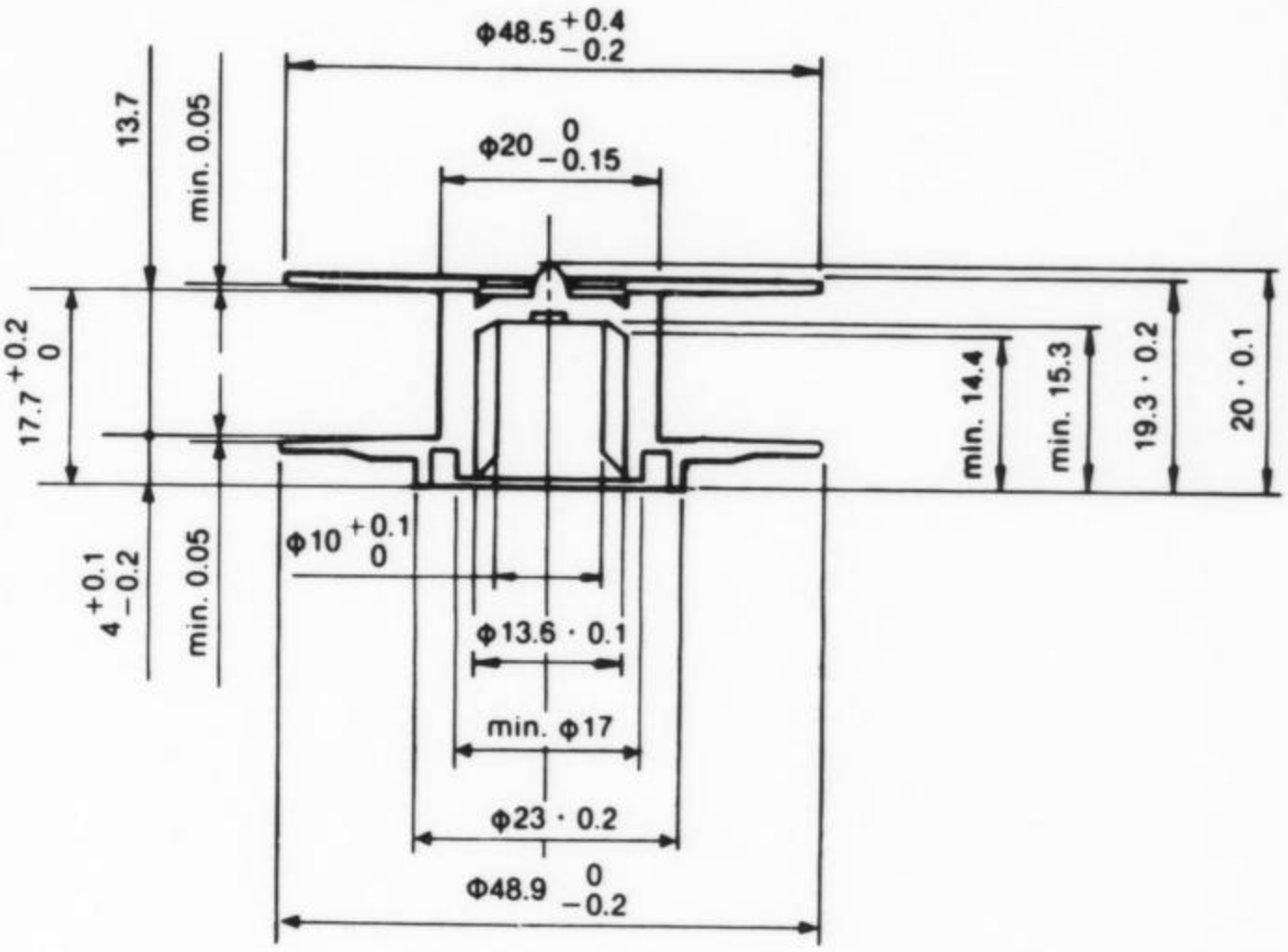


Fig. 14
Supply Reel Dimensions of Small Cassette



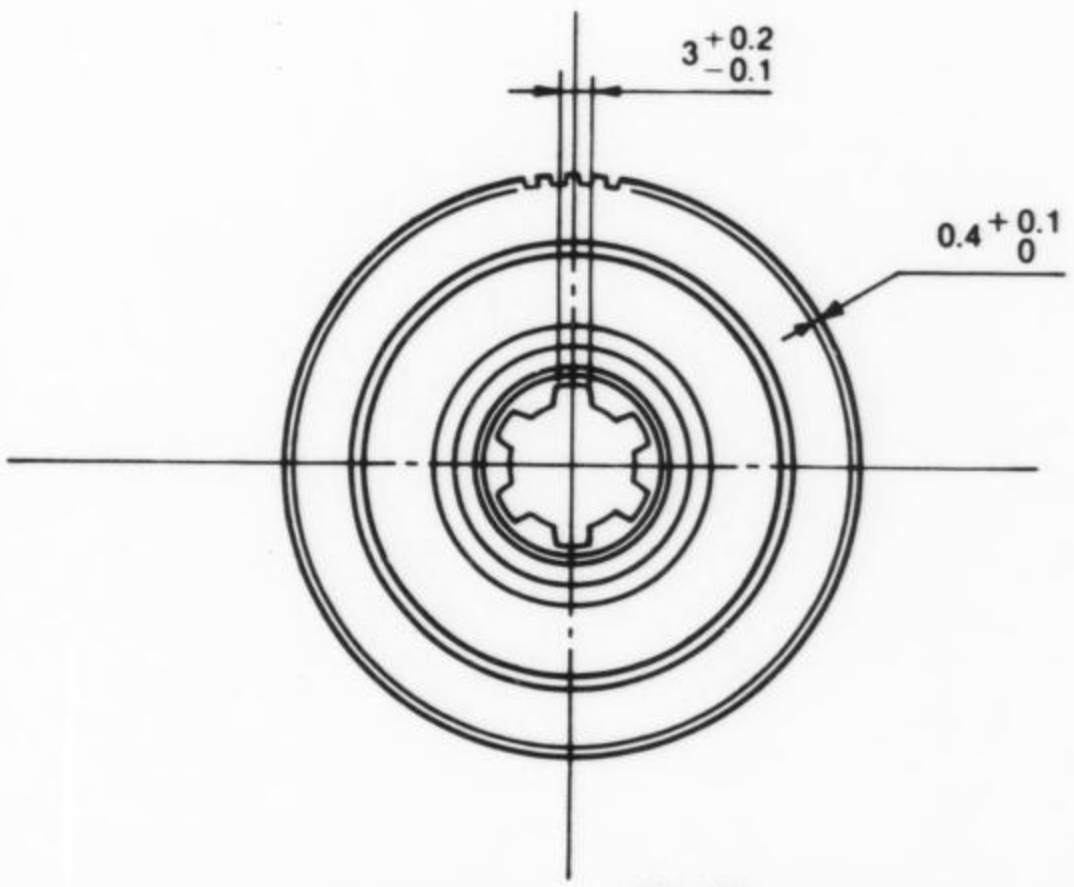


Fig. 15
Take-Up Reel Dimensions of Small Cassette

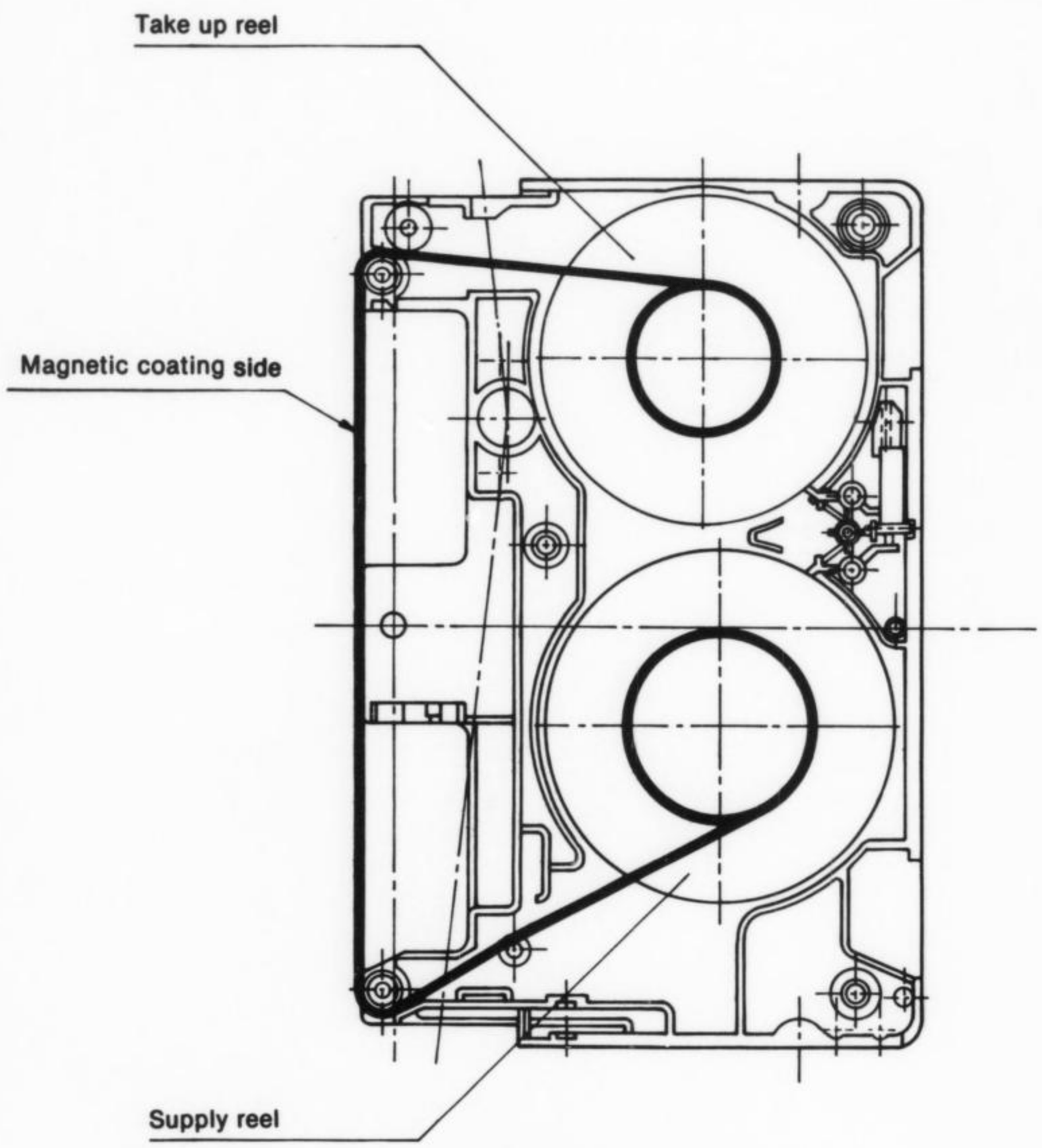


Fig. 16
Tape Path in Small Cassette

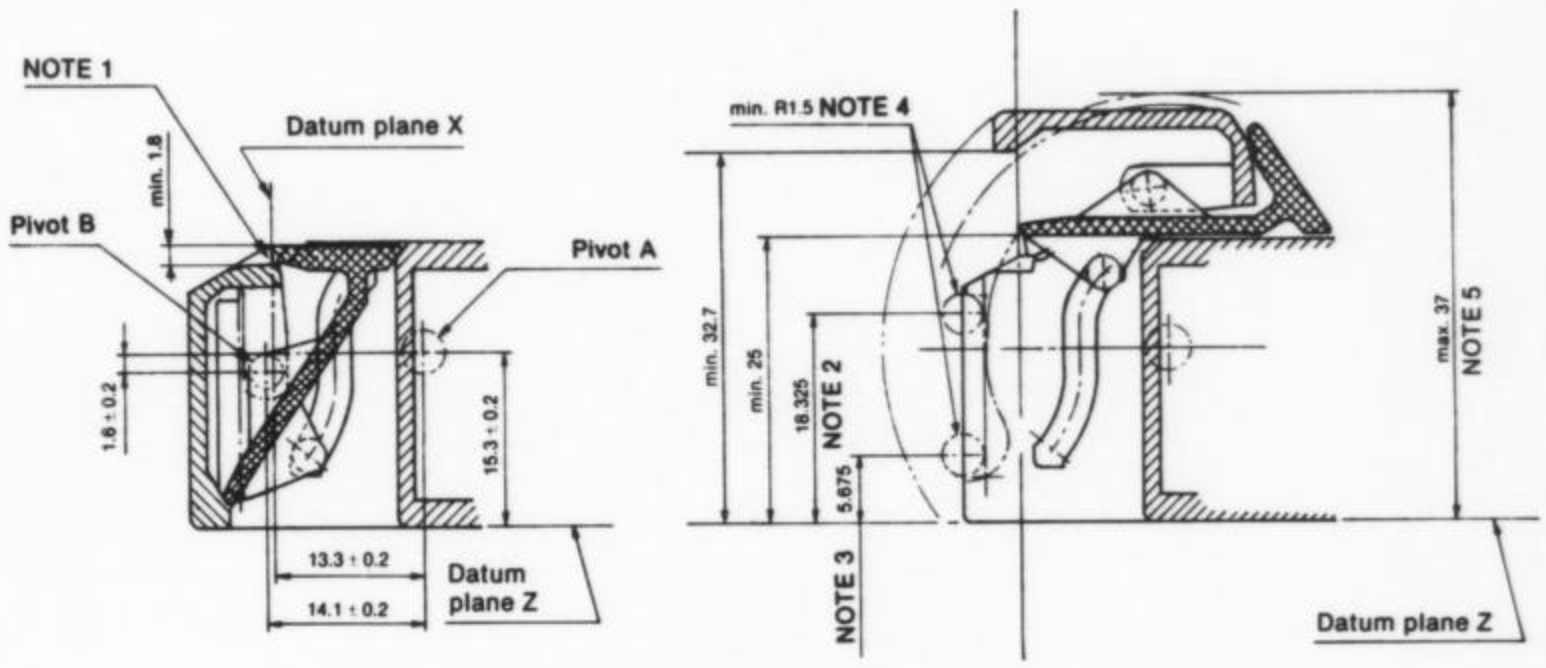


Fig. 17
Lid Structure of Small Cassette

Notes:
1. Recess to prevent misinsertion.
2. Tape upper edge position.
3. Tape lower edge position.
4. Margin for tape position changes shall be 1.5 mm or more.
5. Maximum permissible height when lid is opened.

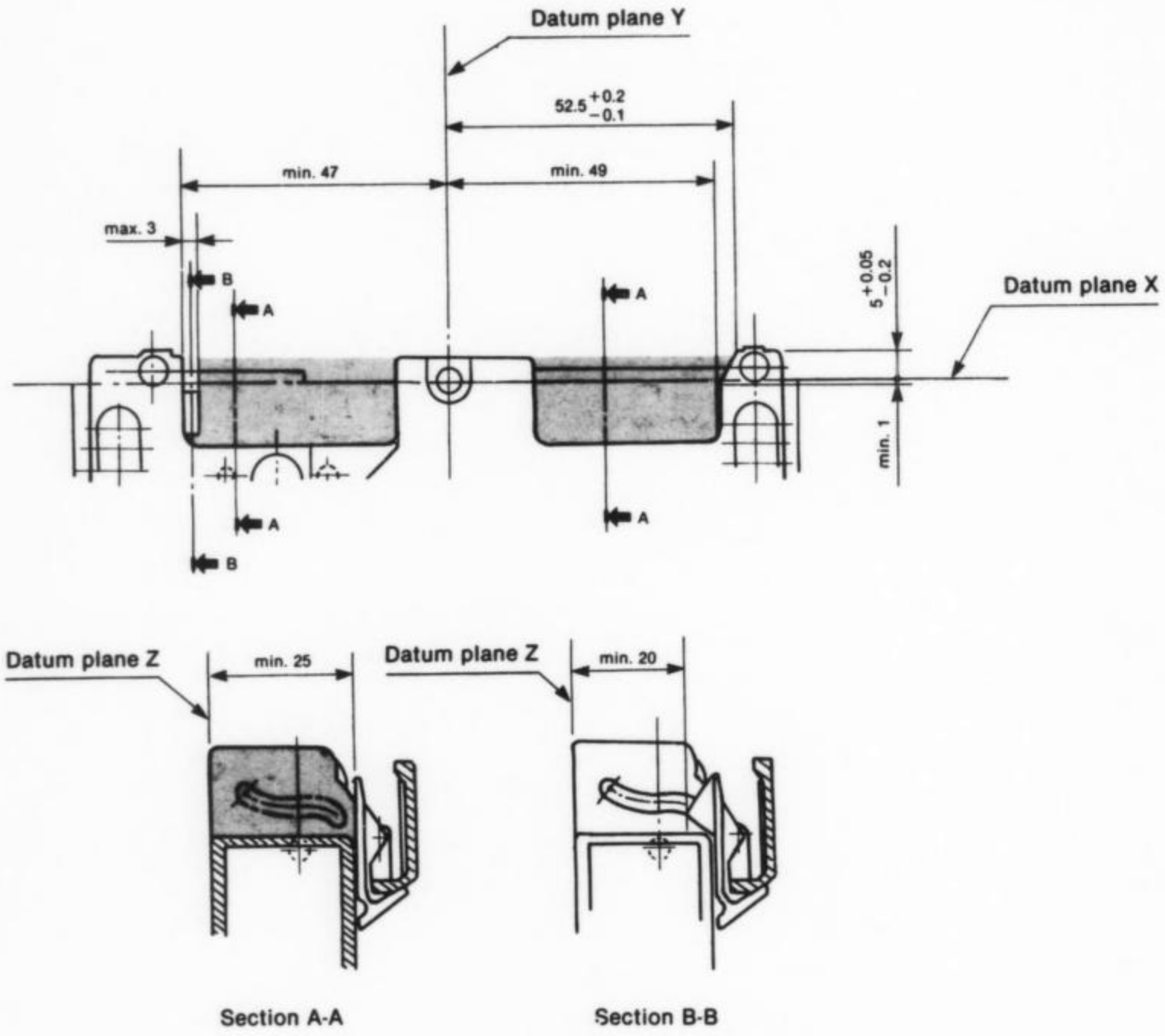


Fig. 18
Minimum Clearance for Recorder and Player Loading Mechanism

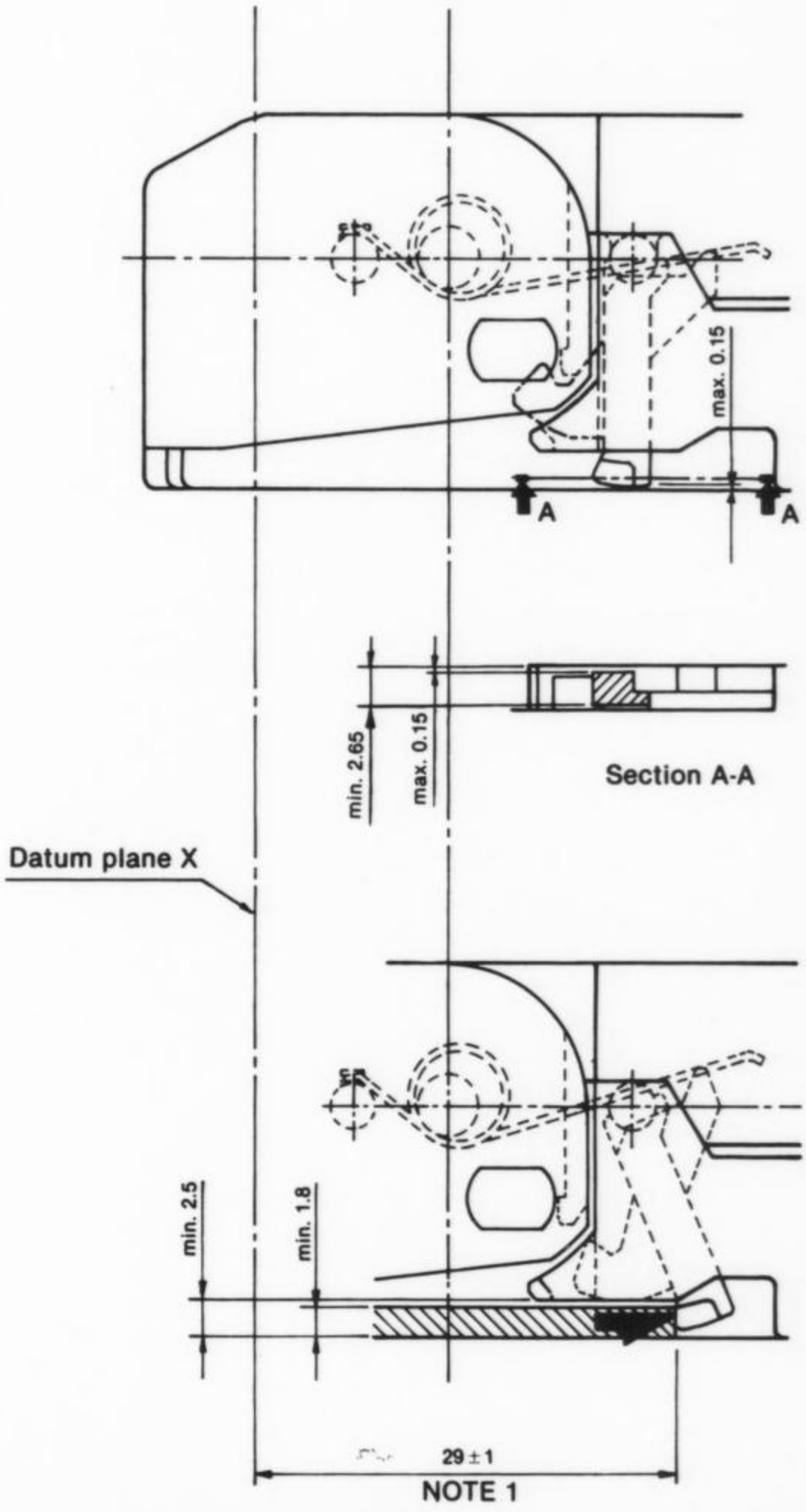


Fig. 19
Unlocking Structure of Lid

Note 1: Lid unlocking position.

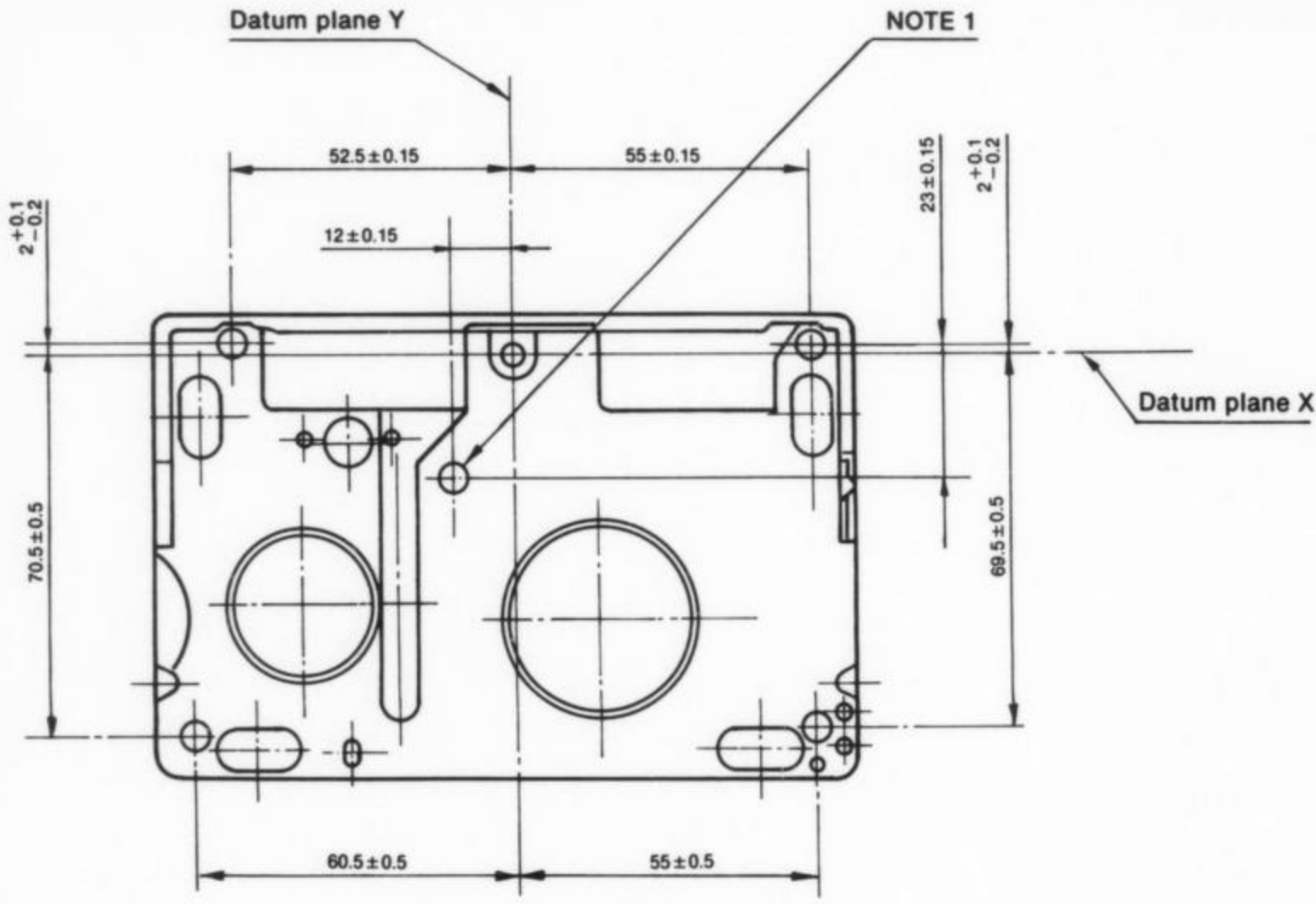


Fig. 20
Screw Positions of Small Cassette

Note 1: The screw position also serves as the positioning point for mounting a small cassette in video tape recorders. The diameter of the spot facing for the screw head of this portion is 5.3 to 5.7 mm, and the depth of the seat to the screw head is 3 mm or more.

Proposed American National Standard

for television analog recording—

½-in type M-2—electrical parameters of video, audio, time and control code and tracking control

SMPTE 251M

1. Scope

1.1 This standard specifies the recording system for the video, audio, time and control code, and tracking-control signals for ½-in type M-2 helical-scan video tape recorders operating with video signals having a typical scanning structure of 525 lines, 59.94 fields/sec, 2:1 interlace, and utilizing the video cassettes specified in SMPTE 250M.

1.2 The audio frequency modulation (AFM) recording shown in this standard is optional. Pulse code modulation (PCM) audio recording mode with limited interchangeability, as defined in SMPTE 249M, is a secondary audio recording mode which is specified in SMPTE 252M.

1.3 Where nominal values are given without tolerances, the interchange performance will be limited by implementation accuracy.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

ANSI/SMPTE 12M-1986, Television — Time and Control Code — Video and Audio Tape for 525-Line/60-Field Systems

SMPTE 249M, Television Analog Recording — ½-in Type M-2 — Records

SMPTE 250M, Television Analog Recording — ½-in Type M-2 — Tapes and Cassettes

SMPTE 252M, Television Analog Recording — ½-in Type M-2 — Pulse Code Modulation Audio

IEEE Std 152-1953, Volume Measurements of Electrical Speech and Program Waves

CCIR Report 624-3, Characteristics of Systems for Monochrome and Colour Television

IEC Publication 268-12 (1975), Circular Connectors for Broadcast and Similar Use

3. Video Signal Recording

Type M-2 video tape recorders shall record component video signals and are intended to operate interchangeably in an NTSC environment. This component video recording system shall provide independent signal channels for the luminance and chrominance signals. These component signals shall be recorded on two independent tracks on the video tape as frequency modulated signals. The two separate tracks shall be designated as the Y track for the luminance signals and the C track for the chrominance signals. The chrominance signals, in the form of R-Y and B-Y color-difference signals, shall be recorded in the form of a time compressed and time division multiplexed signal on the C track. (The AFM audio signal recording shall be recorded in the form of a frequency multiplexed signal together with the FM color-difference signal on the C track.) The PCM audio signal shall be recorded using the luminance and chrominance heads on the luminance and chrominance tracks.

3.1 Luminance Channel

3.1.1 Signal Processing. A signal processing system, as specified in this standard, shall contain the following elements in the order of signal flow:

(1) Means for adding a timing burst signal to the luminance signal

(2) Means for adding vertical interval subcarrier when appropriate

THIS PROPOSAL IS PUBLISHED FOR COMMENT ONLY

(3) A luminance nonlinear preemphasis circuit

(4) A luminance preemphasis network

(5) Means for clipping the preemphasized luminance signal to the amplitude of the modulating frequencies

(6) A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies

(7) A circuit for mixing the PCM audio CH5 signal to the frequency modulated luminance signal

(8) The recording current amplifier for the Y track video heads

3.1.2 Burst Signal Addition. The resultant waveforms when the burst signal is added to the luminance signal shall be as shown in Figs. 1 to 3. Burst frequency (2.25 MHz) is locked to horizontal line frequency.

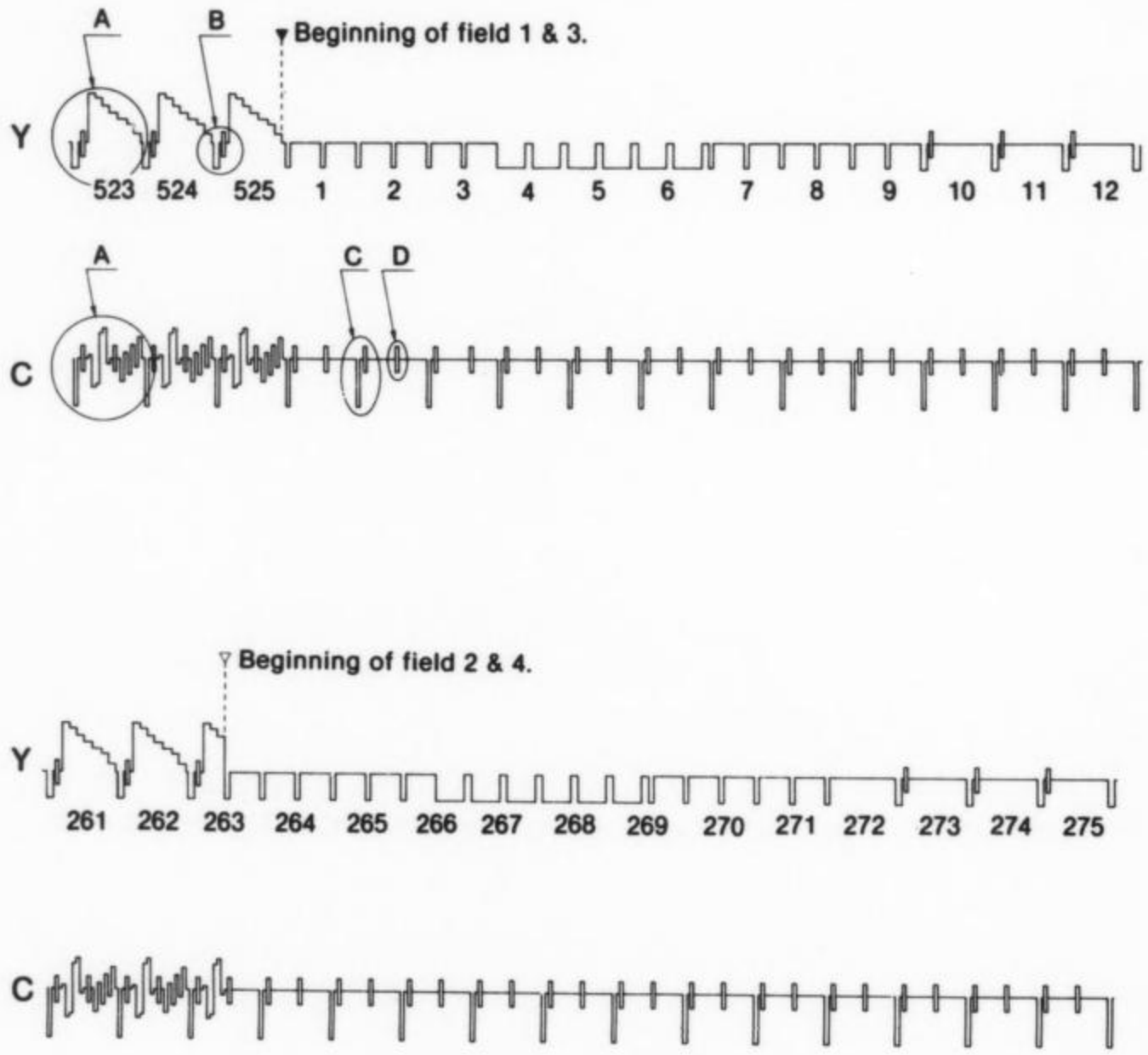


Fig. 1
Waveform of Burst Mixed Luminance and Burst and Sync Added Chrominance Signals

Note: No burst signals are mixed during the 9H period of Y vertical blanking.

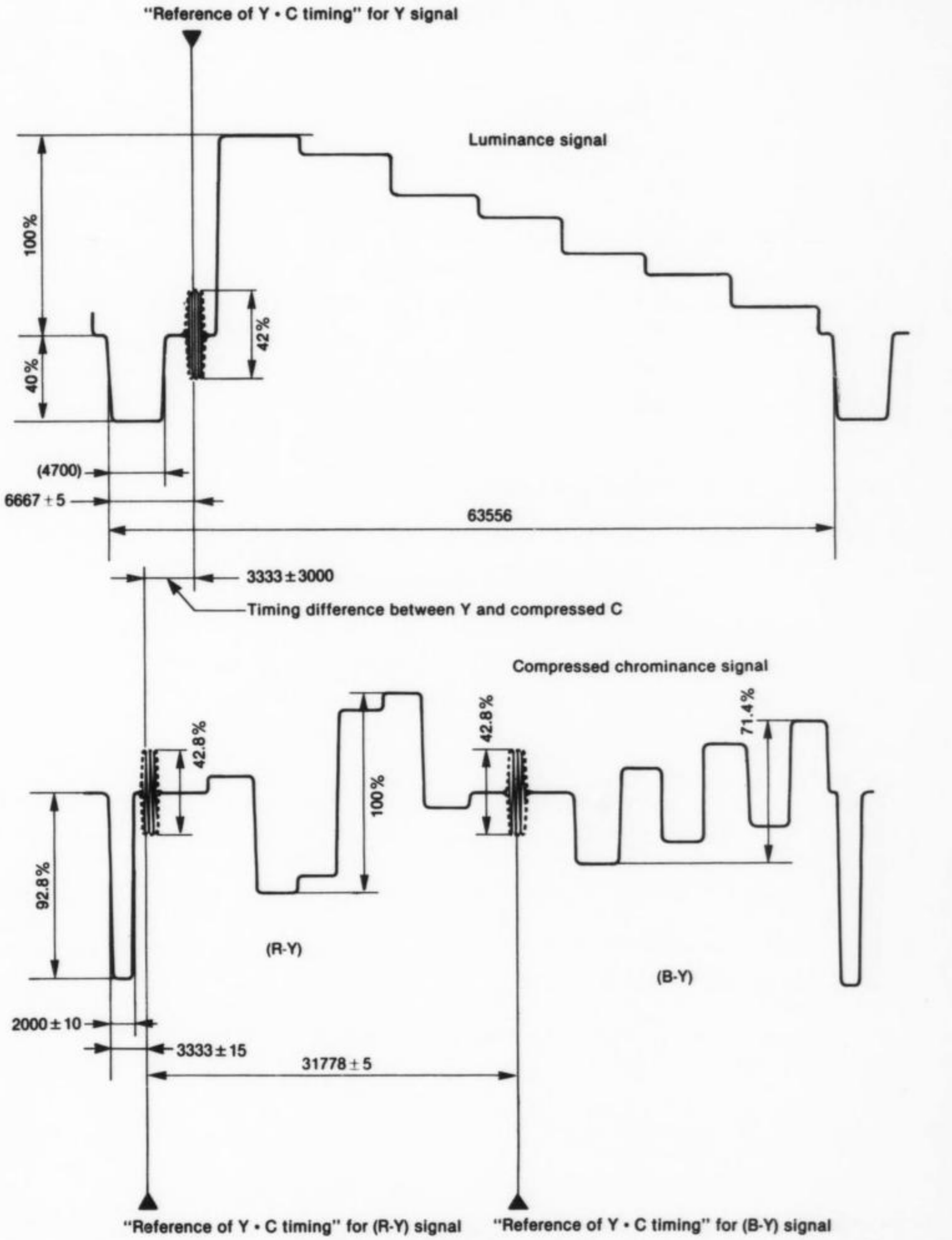


Fig. 2
Luminance Signal and Compressed Chrominance Signals for 100/7.5/77/7.5 Color Bars (Details of Fig. 1A)

Note: Time base in nanoseconds.

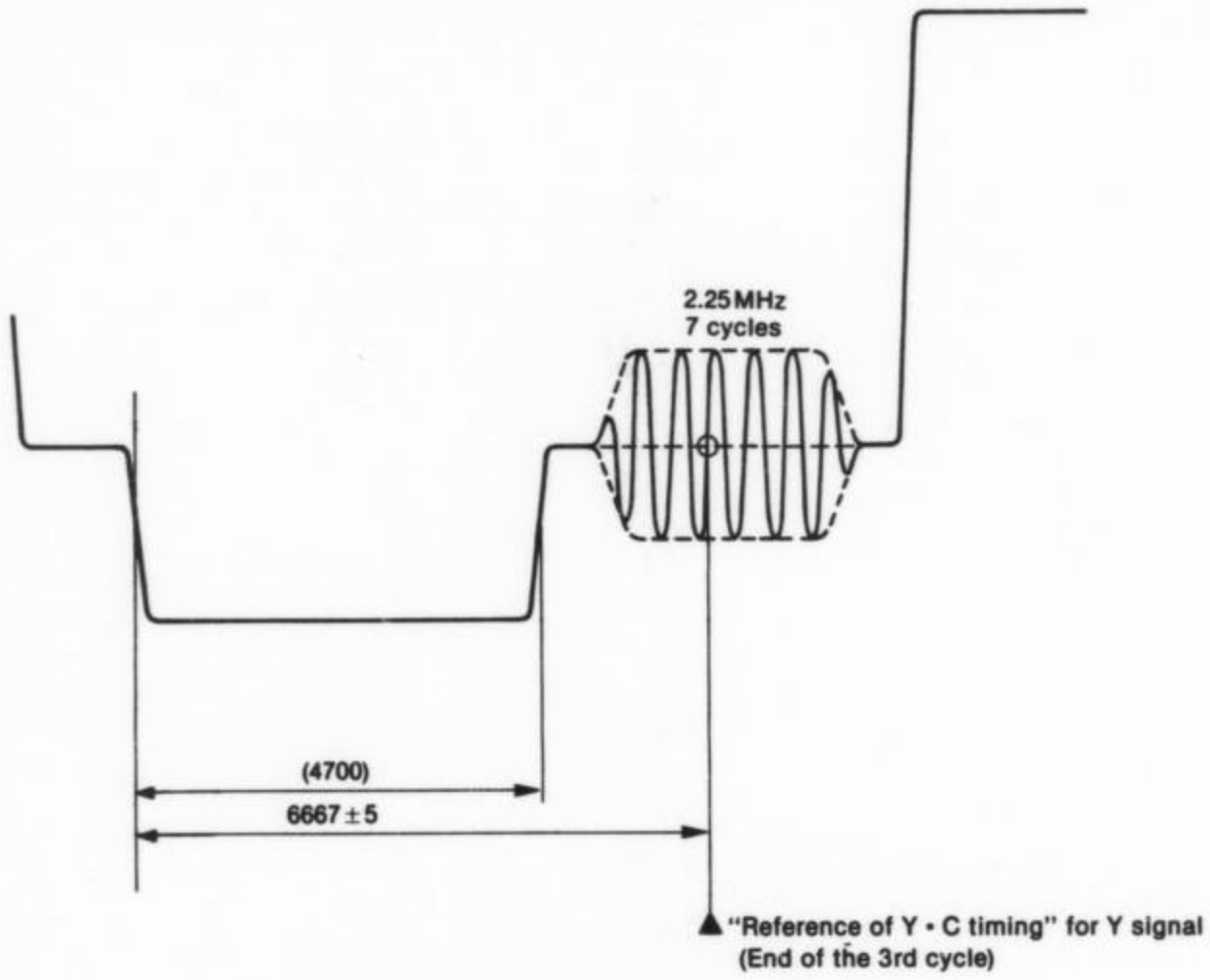


Fig. 3
Details of Fig. 1B

Note: Time base in nanoseconds.

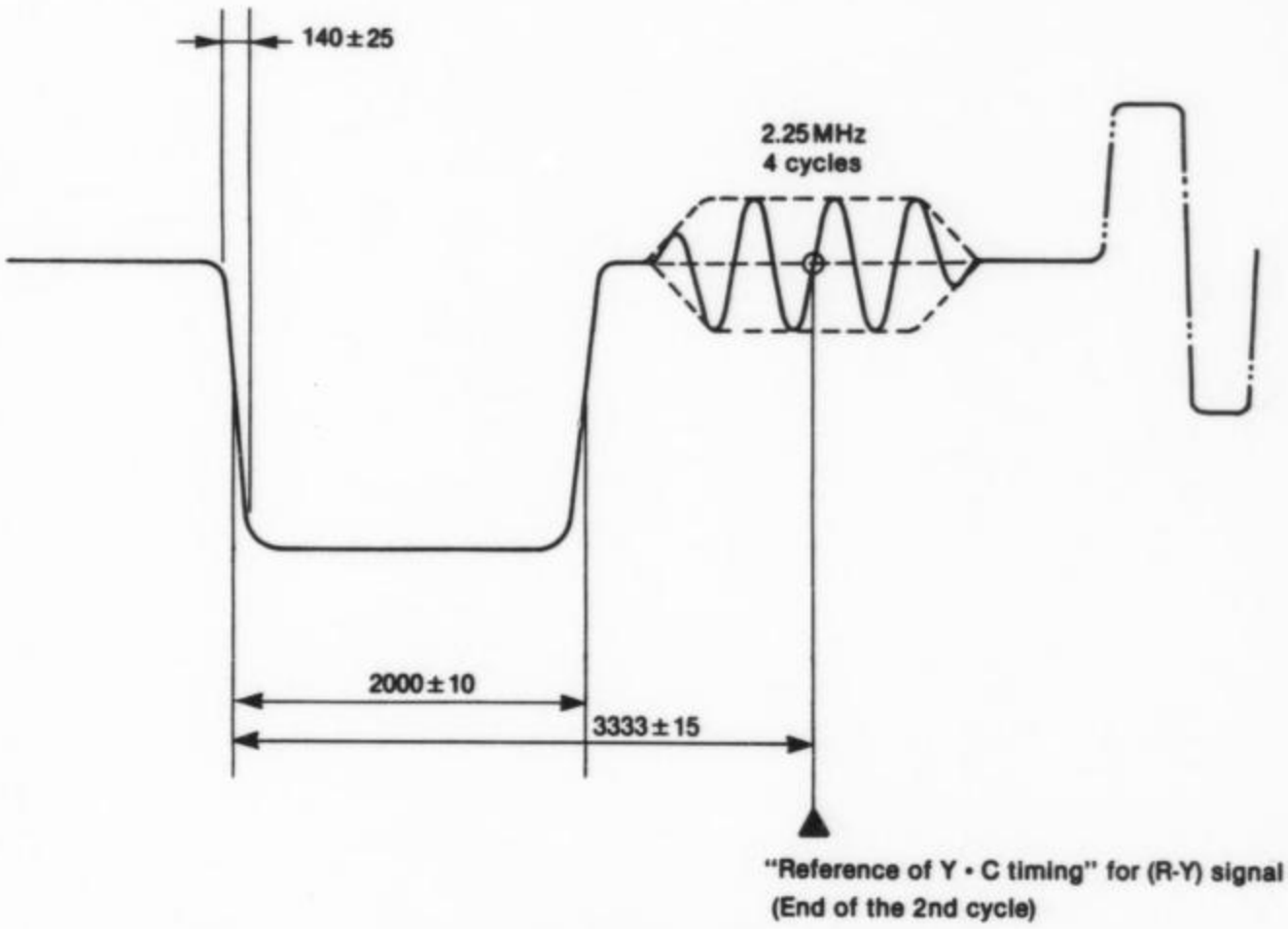


Fig. 4
Details of Fig. 1C

Note: Time base in nanoseconds.

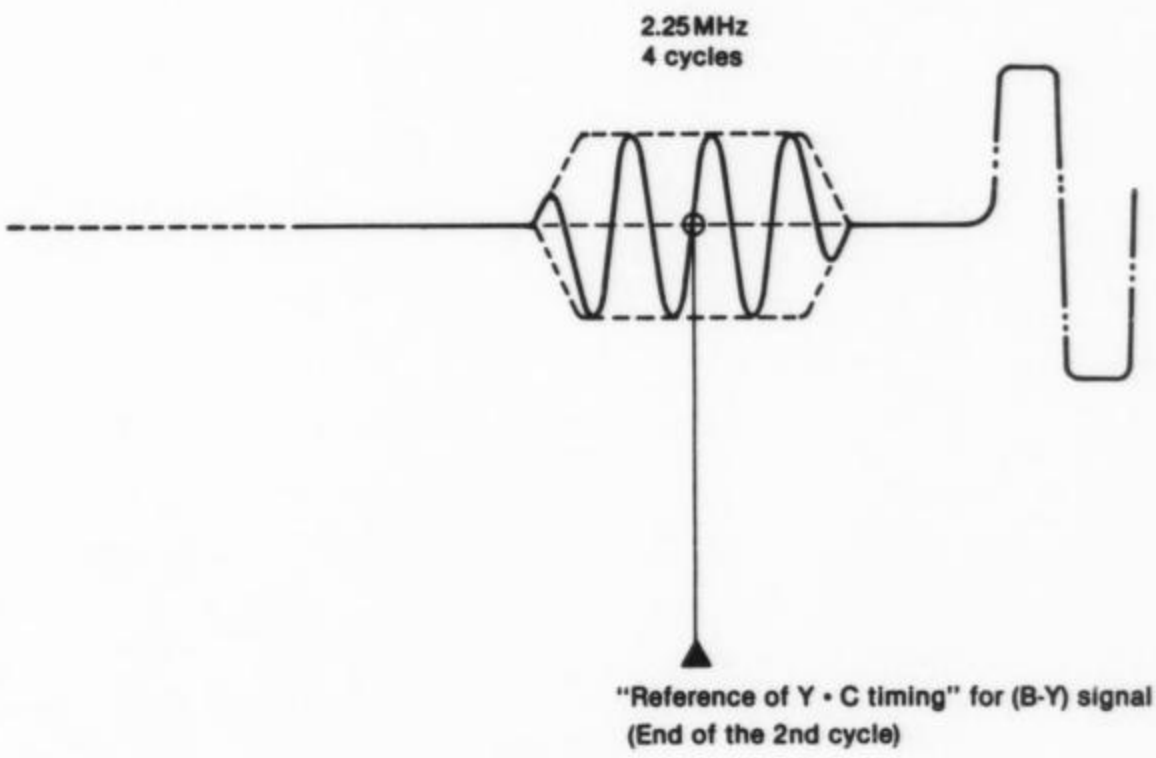


Fig. 5
Details of Fig. 1D

Note: Time base in nanoseconds.

3.1.3 Luminance Nonlinear Preemphasis. The typical frequency characteristics of the nonlinear preemphasis circuit output signal are as shown in Table 1.

Table 1
Luminance Nonlinear Preemphasis Circuit Output Signal

Frequency (MHz)	Relative Input Level (dB) 0	— 10	— 20
0.01	0	0	0
0.1	— 0.1	— 0.2	0.1
0.2	— 0.4	0.1	0.4
0.5	— 0.7	1.1	1.7
1.0	0	3.0	4.0
2.0	0.9	4.8	6.1
3.0	1.3	5.5	6.8
5.0	1.7	6.1	7.2

Notes: 1. A block diagram of a nonlinear preemphasis circuit is shown in Fig. 6.

2. Values are in decibels.

3.1.4 Luminance Preemphasis. The network and circuit parameters shall be as shown in Fig. 7.

3.1.5 Amplitude Clipping. For an input signal where blanking is at 0% and peak white at 100%, any positive or negative amplitude excursion exceeding the limits shown below shall be clipped:

Positive excursion limit	+ 338% (nominal)
	+ 348% (maximum)
Negative excursion limit	— 190% (nominal)
	— 200% (maximum)

3.1.6 FM Carrier Frequency. Carrier frequencies corresponding to the reference video level shall be as follows:

100% white	7.70 MHz (nominal)
50% level	6.95 MHz (nominal)
Blanking	6.20 MHz ± 0.05 MHz
Sync tip	5.60 MHz (nominal)
Video deviation	1.50 MHz ± 0.05 MHz

3.1.7 Y Track Record Head Current

3.1.7.1 The amplitude of the record current for the Y track shall be such that the maximum level of remanent flux on the tape is produced when recording a Y signal with 50% average picture level.

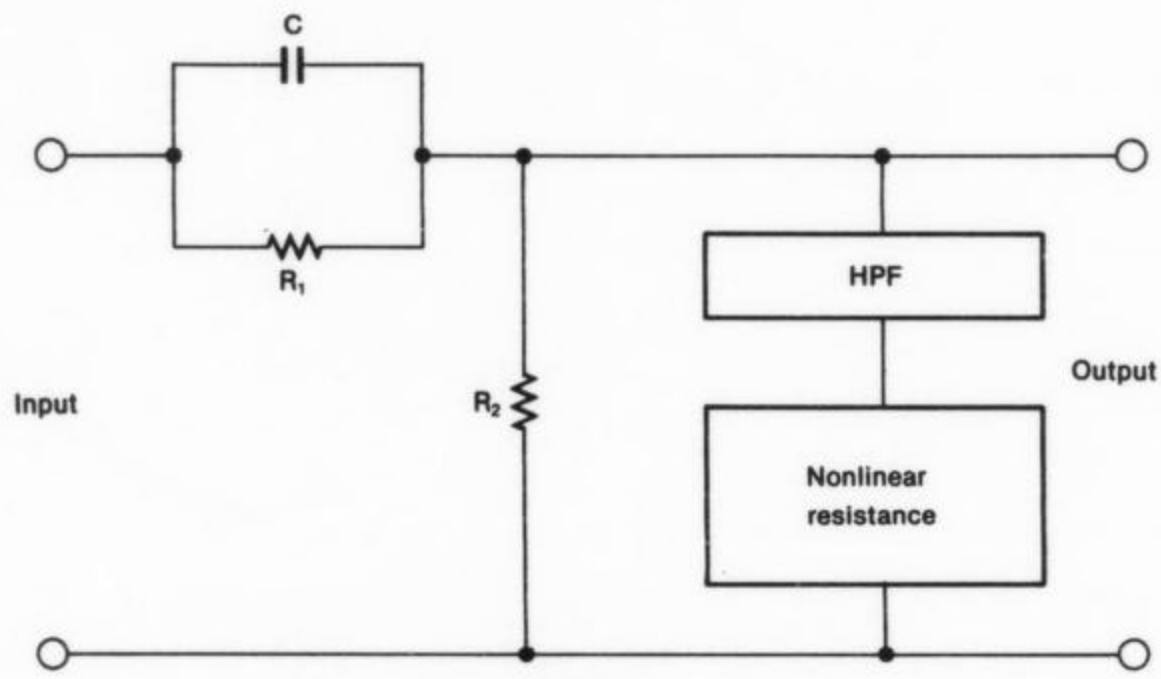
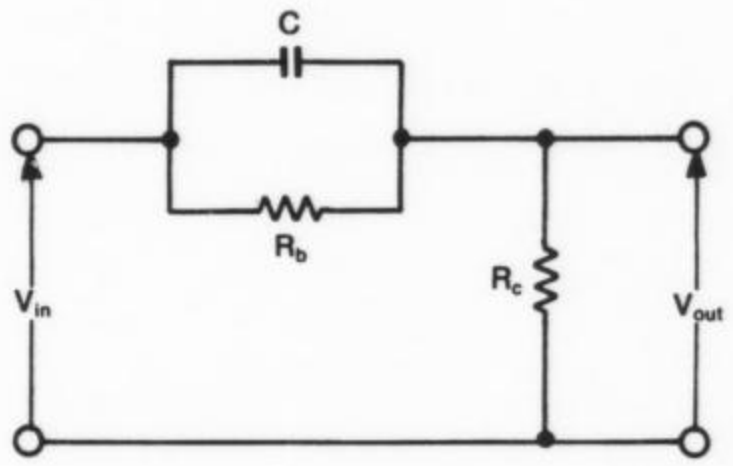


Fig. 6
Luminance Nonlinear Preemphasis Circuit

Note: The input signals are fed from the zero impedance source, and the output signals are applied to the infinite impedance load.



$$T_Y = CR_b = 1.34\ \mu s$$

$$X_Y = R_b/R_c = 2.5$$

$$\frac{V_{out}}{V_{in}} = \frac{1 + j\omega T_Y}{1 + X_Y + j\omega T_Y}$$

Fig. 7
Luminance Preemphasis Network

Note: Input source impedance = 0; output load impedance = ∞.

3.1.7.2 The amplitude of the Y track record current shall decrease with increasing frequency according to a straight line in the range of 2 to 10 MHz contained within limit lines as shown in Fig. 11.

3.2 Chrominance Channel

3.2.1 Signal Processing. A signal processing system, as specified by this standard, shall contain the following elements in the order of the signal flow:

(1) Means for adding a horizontal sync pulse and the timing burst signals to the chrominance signal

(2) Means to individually adjust the R-Y and B-Y levels in the ratio specified

(3) Means to perform the time compression and time-division multiplexing of the R-Y and B-Y color difference signals

(4) A chrominance nonlinear preemphasis circuit

(5) A chrominance preemphasis network

(6) Means for clipping the preemphasized chrominance signal

(7) A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies

(8) A high-pass filter to reduce the amplitude of low-frequency components to allow for the mixing of the optional AFM signals

(9) A circuit to mix the optional AFM signals with the chrominance signal

(10) A circuit for mixing the PCM audio CH6 signal to the frequency modulated chrominance signal

(11) A recording current amplifier for the C track video heads

3.2.2 Addition of Burst and Sync Signals. Resultant signal waveforms shall be as shown in Figs. 1, 2, 4, and 5.

3.2.3 Time Compression and Multiplexing. The time compression factor shall be one half. The time compressed R-Y and B-Y signals shall be multiplexed alternately as shown in Fig. 8. The compressed and multiplexed R-Y and B-Y signals shall be delayed by one horizontal line with respect to the luminance signal.

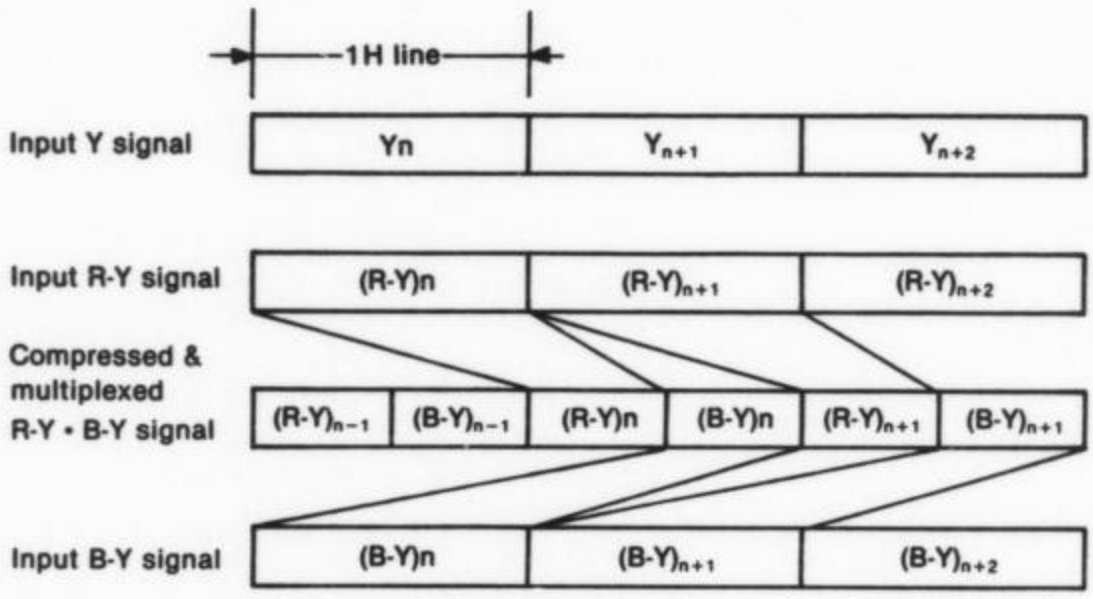


Fig. 8
Time-Base Compression and Multiplexing

3.2.4 Chrominance Nonlinear Preemphasis. A block diagram of a nonlinear preemphasis circuit is shown in Fig. 9. The typical frequency characteristics of this nonlinear preemphasis circuit output signal are as shown in Table 2.

3.2.5 Chrominance Preemphasis. The network and circuit parameters shall be as shown in Fig. 10.

3.2.6 Amplitude Clipping. For an input signal of "100/7.5/77/7.5" color bars (100% level), any positive or negative amplitude ex-

Table 2
Chrominance Nonlinear Preemphasis Circuit Output Signal

Frequency (MHz)	Relative Input Level (dB) 0	— 10	— 20
0.01	0	0	0
0.1	— 0.3	— 0.3	— 0.1
0.2	— 0.5	— 0.1	0.2
0.5	— 0.2	1.1	1.6
1.0	0.6	3.0	3.9
2.0	1.5	4.8	6.0
3.0	1.9	5.5	6.6

Note: Values are in decibels.

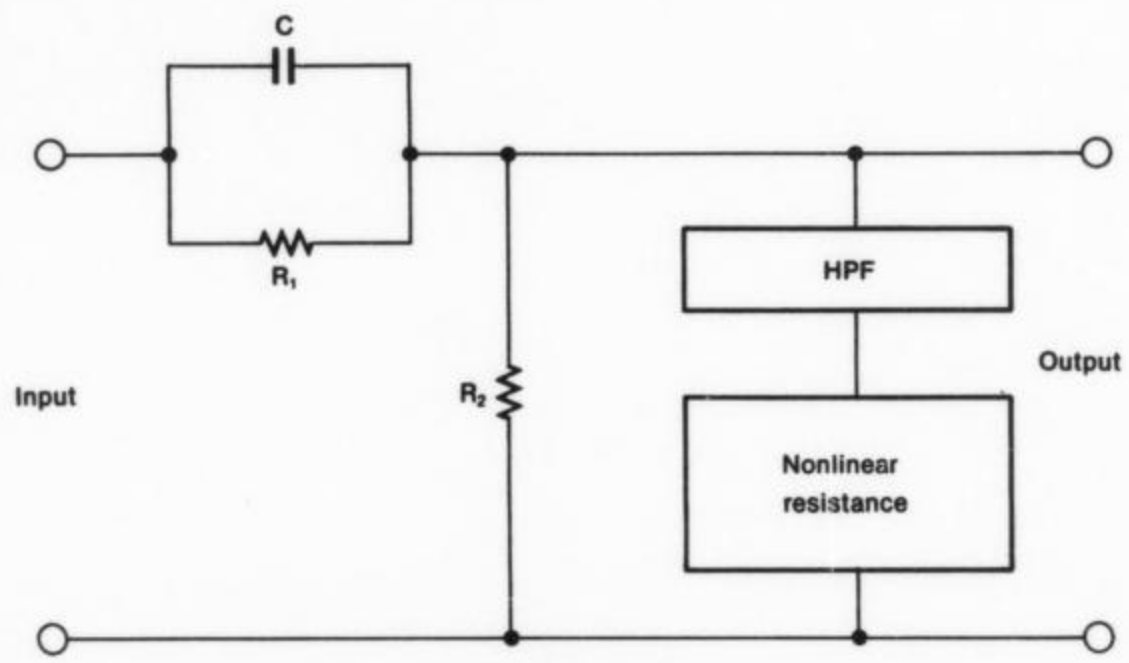
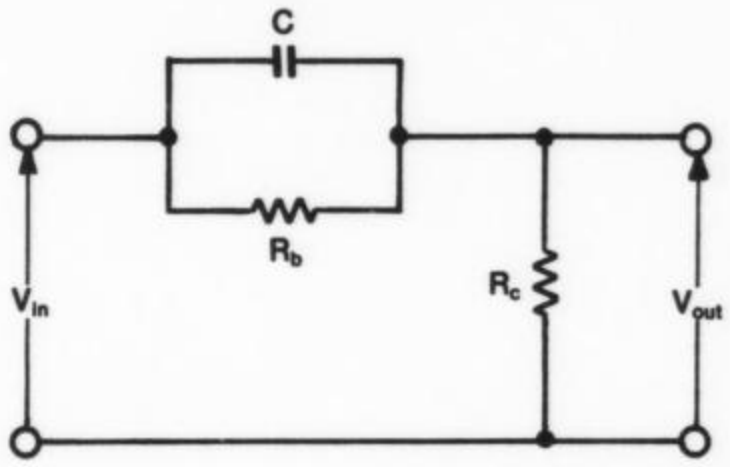


Fig. 9
Chrominance Nonlinear Preemphasis Circuit

Note: The input signals are fed from the zero impedance source and the output signals are applied to the infinite impedance load.



$$T_c = CR_b = 0.60\ \mu s$$

$$X_c = R_b/R_c = 2.5$$

$$\frac{V_{out}}{V_{in}} = \frac{1 + j\omega T_c}{1 + X_c + j\omega T_c}$$

Fig. 10
Chrominance Preemphasis Network

Note: Input source impedance = 0; output load impedance = ∞.

cursion exceeding the limits shown below shall be clipped:

Positive excursion limit	+ 147.7% (nominal)
	+ 157.7% (nominal)
Negative excursion limit	— 180.2% (nominal)
	— 190.2% (maximum)

3.2.7 FM Carrier Frequency. Carrier frequencies corresponding to reference video levels shall be as shown in Table 3.

Table 3
Carrier Frequencies and Reference Video Levels

	100/7.5/77/7.5 Color Bar Signal	
	R-Y	B-Y
Peak of positive excursion	6.20	6.00
Peak of negative excursion	4.80	5.00
Blanking	5.50	5.50
Sync-tip	4.20	—
Maximum p-p deviation	1.40	1.00
Deviation p-p tolerance	± 0.02	± 0.015
Blanking carrier tolerance	± 0.05	± 0.05

Note: Frequency in megahertz.

3.2.8 C Track Record Head Current

3.2.8.1 The amplitude of the record current for the C track shall be such that the maximum level of remanent flux on the tape is produced when recording the chrominance blanking level.

3.2.8.2 The amplitude of the C track record current shall decrease with increasing frequency according to a straight line in the range of 2 to 10 MHz contained within limit lines as shown in Fig. 11.

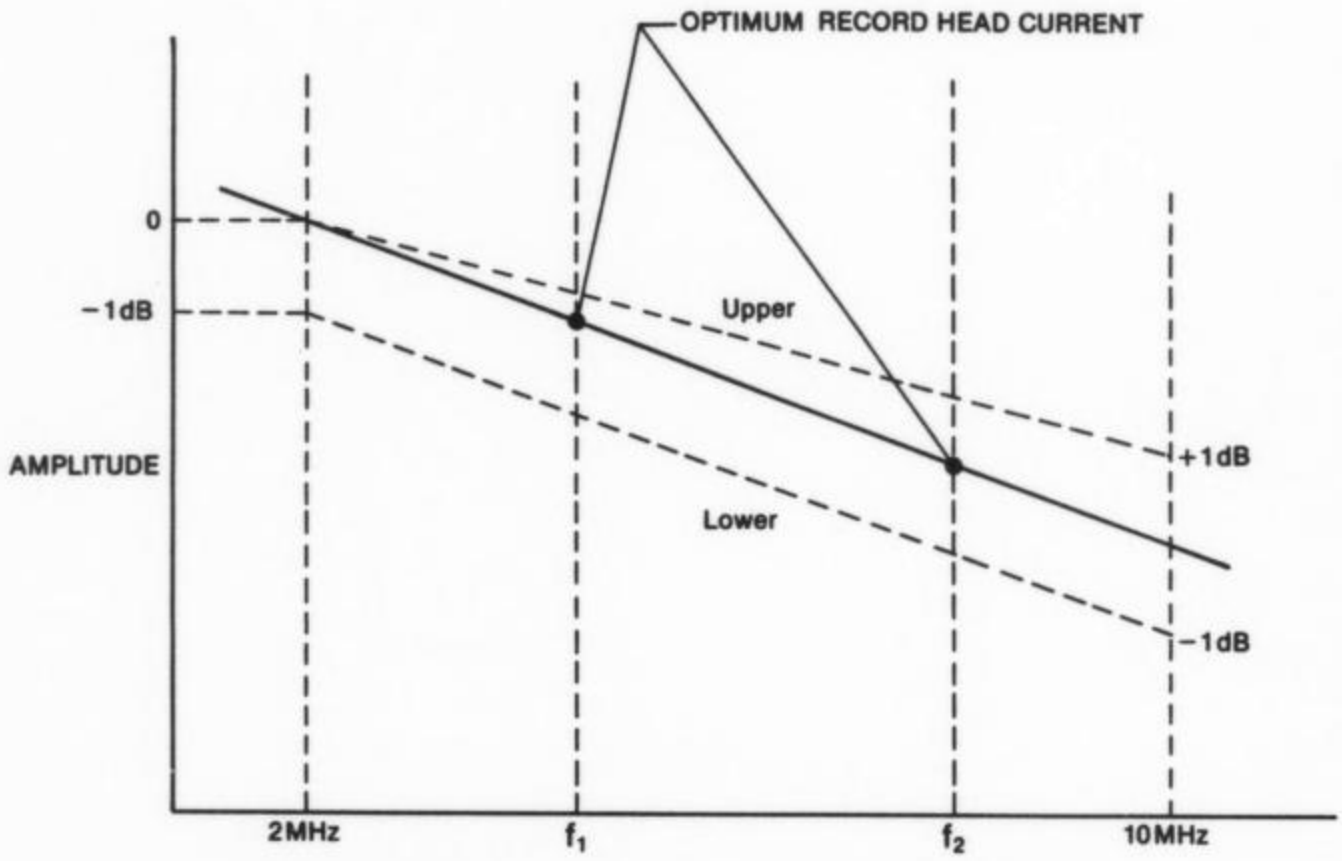
3.2.9 The frequency characteristics of the recording current shall be as shown in Table 4.

Table 4
Recording Current Characteristics

Frequency (MHz)	Relative Level (dB)
0.4	Less than — 30
0.7	Less than — 30
2.0	0

3.3 Y-C Timing

3.3.1 Reference of Y-C Timing. The timing difference between the Y signal, the R-Y, and the B-Y signal before time compression shall not be more than 5 ns as shown in Fig. 12.



Luminance Channel	Chrominance Channel
f_1 Blanking frequency	Minimum chroma frequency
f_2 100% white frequency	Maximum chroma frequency

Fig. 11
Record Equalization

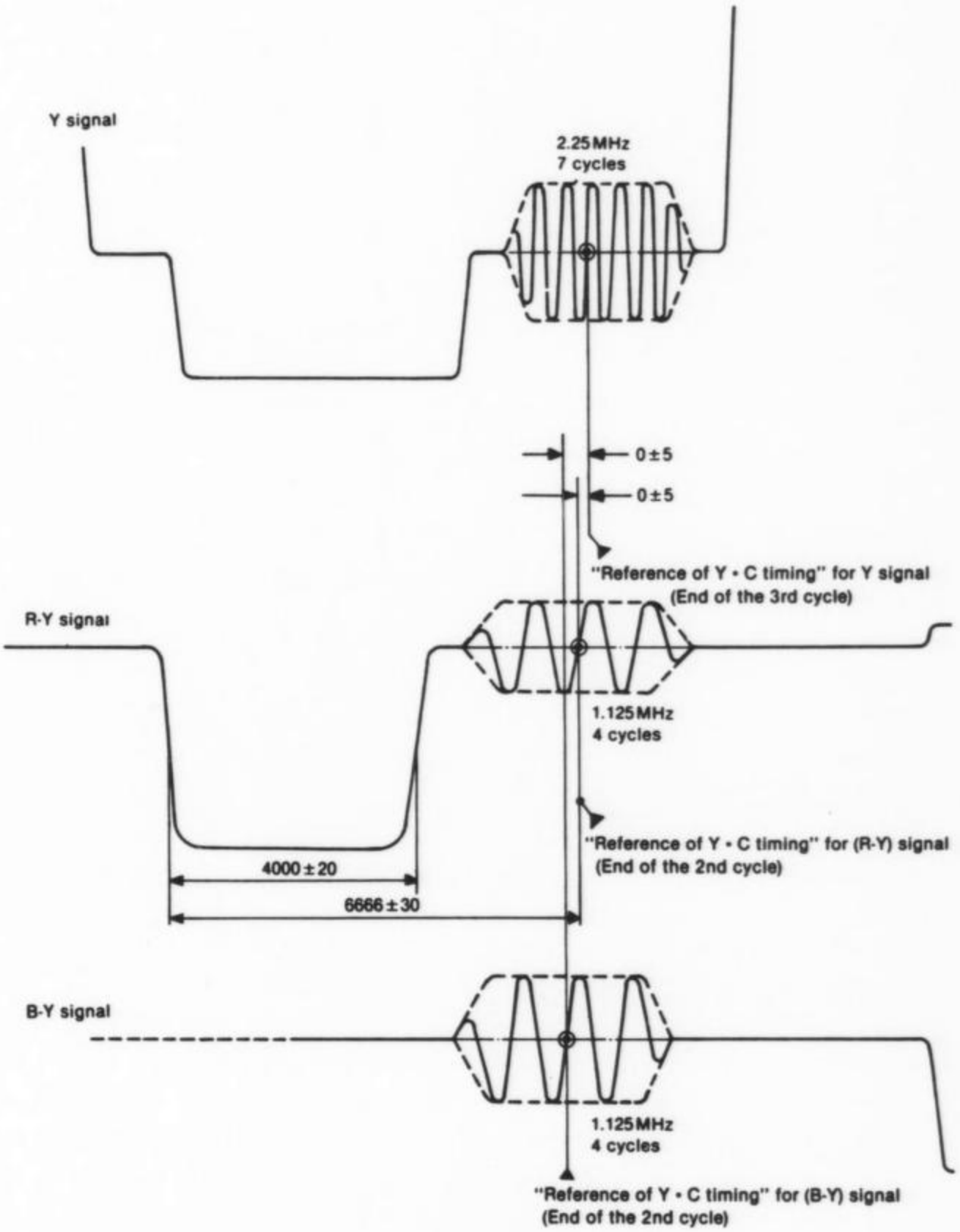


Fig. 12
Reference of Y-C Timing

Notes: 1. Time base in nanoseconds.
2. Reference of Y-C timing shown displaced for illustrative purposes.

3.3.2 Tolerance of Compressed Y-C Timing. The timing difference between the luminance and the compressed chrominance signals shall be the value as shown in Fig. 2.

3.4 Vertical Interval Subcarrier (VISC)

3.4.1 VISC shall consist of one line of subcarrier inserted into each field of the Y signal as shown in Fig. 13. This signal shall only be present when the signal to be recorded is the result of decoding a composite NTSC signal with coherent subcarrier.

3.4.2 The frequency of the VISC signal shall be equal to the frequency of the subcarrier of the NTSC video signal.

3.4.3 The phase of VISC signal shall be within $\pm 5°$ of the burst phase of the NTSC signal prior to decoding.

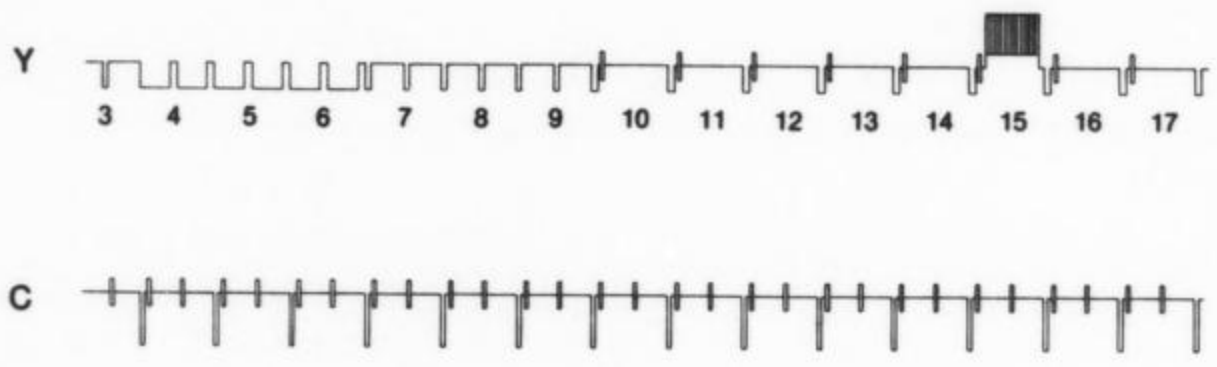
4. Longitudinal Audio Signal Recording

4.1 Recording Method. Recordings shall be made by the anhysteretic (bias) method.

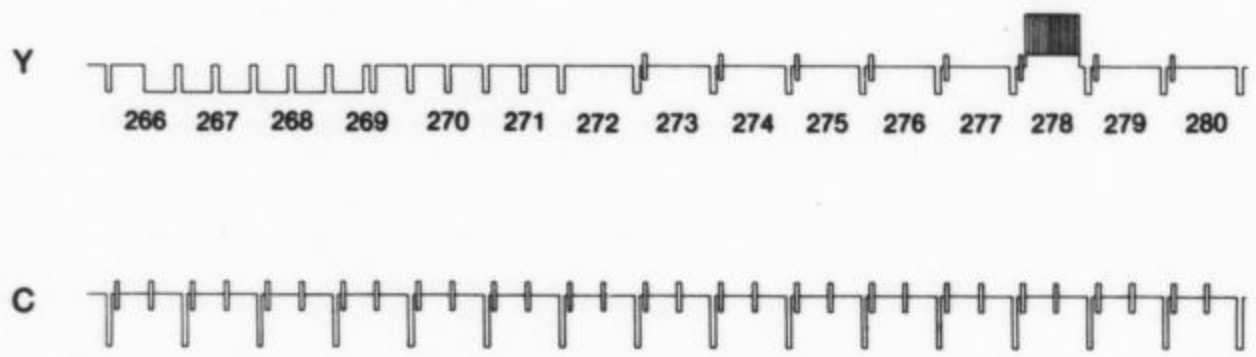
4.2 Recording/Reproducing Reference Levels

4.2.1 Recording/Reproducing Level Indicator. The audio recording and reproducing levels of this recorder shall be determined by using a

Fields 1 and 3



Fields 2 and 4



Detail of VISC Signal

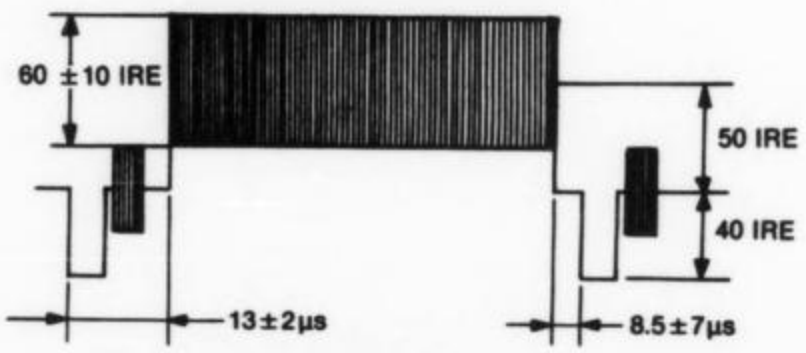


Fig. 13
Waveforms of VISC Signal

standard volume indicator or its equivalent as specified in IEEE Std 152-1953.

4.2.2 Recorder Reference Level. For a 1-kHz sinusoidal signal recording which yields an rms short circuit tape flux per unit track width on the record of 100 nWb/m ± 3 nWb/m, the recording volume indicator shall indicate its reference level scale mark.

4.2.3 Reproducer Reference Level. For the reproduction of 1-kHz tape record which yields an rms short circuit tape flux per unit track width of 100 nWb/m, the reproducing volume indicator shall indicate its reference level scale mark.

4.3 Frequency Characteristics

4.3.1 Record Flux Versus Frequency Characteristics. When a tape is recorded from a constant voltage applied to the input terminals, the short circuit tape flux level in the record versus frequency characteristics, $L_\phi(f)$, shall be expressed by the following equation:

$$L_\phi(f) = 10 \log_{10} \frac{1 + (F_1/f)^2}{1 + (f/F_h)^2} \text{ (dB)}$$

where

$L_\phi(f)$ is the relative tape flux level

f is the frequency at which the response is calculated

F_1 is the low-frequency transition frequency, 50 Hz

F_h is the high-frequency transition frequency, 4681 Hz

4.3.2 Reproduced Flux Versus Frequency Characteristics. When a tape record having a short-circuit tape flux level versus frequency characteristics given by 4.3.1 is reproduced, the output voltage level of the reproducer versus frequency characteristics shall remain constant.

4.3.3 Noise Reduction Characteristics. A noise reduction process, if applied, shall have the static encoding characteristics shown in Table 5.

Table 5
Longitudinal Audio Frequency Response of Noise Reduction Encoding Level

Frequency (Hz)	Input Level (dB) 0	—10	—20	—30	—40	—50	—60
100	0.2	0.9	2.7	2.9	2.9	2.9	2.9
200	0.1	1.5	5.3	8.0	8.1	8.1	8.1
300	0	1.6	6.1	10.7	12.0	12.0	12.0
500	0	1.7	6.3	11.8	15.6	16.2	16.2
1k	—0.3	1.5	5.9	11.4	16.2	19.4	19.6
3k	—1.6	—0.1	3.7	9.2	13.9	19.2	20.7
5k	—2.3	—0.6	2.9	8.4	13.5	18.7	20.4
10k	—3.5	—1.4	2.6	8.2	13.6	18.1	19.2
15k	—6.3	—3.3	1.5	7.3	12.2	15.0	15.0

Notes: 1. Input level is 0 dB, the reference input level at 1 kHz.
2. Encode level is 0 dB, the recorded reference level specified by 4.2.2.
3. Values are in decibels.

4.4 Track Usage (Common Audio Mode)

4.4.1 Nonstereo Audio. The primary program audio channel shall be recorded on the audio 1 track.

4.4.2 Stereo Audio. When separate channels are used for stereo audio, the left channel shall be recorded on the audio 1 track, and the right channel on the audio 2 track.

4.5 Program Audio Head Phasing. When the same signal is recorded on audio 1 and audio 2 tracks, the tracks shall be so phased that, when reproduced with a head wide enough to sense the recorded flux on both records, the result will be additive.

4.6 Recording Polarity. When a positive-going waveform is present on pin-2 of the input connector, as defined in IEC Publication 268-12

(1975), the audio head gap shall produce the magnetic flux which flows out of the north pole and into the south pole. This flux flow shall be in the direction of tape movement.

5. AFM Signal Recording (Optional)

Audio signals of two channels shall frequency modulate two carriers. These frequency modulated carriers shall be located in the frequency region below the lower side band of the frequency modulated chrominance signal, which is specified by 3.2, in order to produce a frequency multiplex signal. The resultant multiplex signal shall be recorded on the chrominance track.

5.1 Signal Processing. A signal processing system as specified by this standard shall contain the following elements:

5.1.1 An audio noise-reduction scheme incorporating compression

5.1.2 A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies

5.1.3 A means for adding the AFM signals to the chrominance signal in the ratios specified

5.2 Recording/Reproducing Reference Levels

5.2.1 Recording/Reproducing Level Indicator. The audio recording and reproducing levels of this recorder shall be determined by using a standard volume indicator or its equivalent as specified in IEEE Std 152-1953.

5.2.2 Recorder Reference Level. When a 1-kHz sinusoidal signal recording is made with the reference deviation defined in 5.5.2, the recording volume indicator shall be adjusted to deflect to its reference level scale mark.

5.2.3 Reproducer Reference Level. When a 1-kHz tape record with the reference deviation defined in 5.5.2 is reproduced, the reproducing volume indicator shall deflect to its reference level scale mark.

5.3 Noise Reduction

5.3.1 Noise Reduction Circuit. A noise reduction circuit or its equivalent shall be as shown in Fig. 14.

5.3.2 Compression Ratio. The compression ratio shall be 2:1 in the logarithmic scale.

5.3.3 Transient Response. The transient response shall be such that an attack time is 9.0 ms ± 3 ms and a recovery time is 90 ms± 30 ms. Dynamic characteristics shall be as shown in Fig. 15.

5.4 Preemphasis. The output signal of the noise-reduction circuit specified in 5.3 shall be preemphasized before the frequency modulation by a network as shown in Fig. 16.

5.5 Frequency Modulation

5.5.1 Carrier Frequency. The left channel (CH3) signal frequency shall be 400 kHz ± 5 kHz. The right channel (CH4) signal frequency shall be 700 kHz ± 5 kHz.

5.5.2 Frequency Deviation. The reference level deviation shall be 35 kHz ± 0.7 kHz at 1 kHz. The maximum deviation shall not exceed ± 105 kHz.

5.6 Recording Head Current. The recording head current level shall be adjusted at 20 dB ± 1 dB below the chrominance recording level defined in 3.2.8. The amplitude of the recording head current shall be constant over the frequency range from 300 to 800 kHz.

6. Time and Control Code Signal Recording

6.1 Designated Track for Time and Control Code. The longitudinal track identified as the time and control code track shall be used for recording the code specified in ANSI/SMPTE 12M-1986.

6.2 Recording Method. The recording shall be made by the anhysteretic (bias) method.

6.3 Recording Level. The recording level, as expressed in peak-to-peak short circuit tape flux per unit track width, shall be 250 nWb/m ± 50 nWb/m.

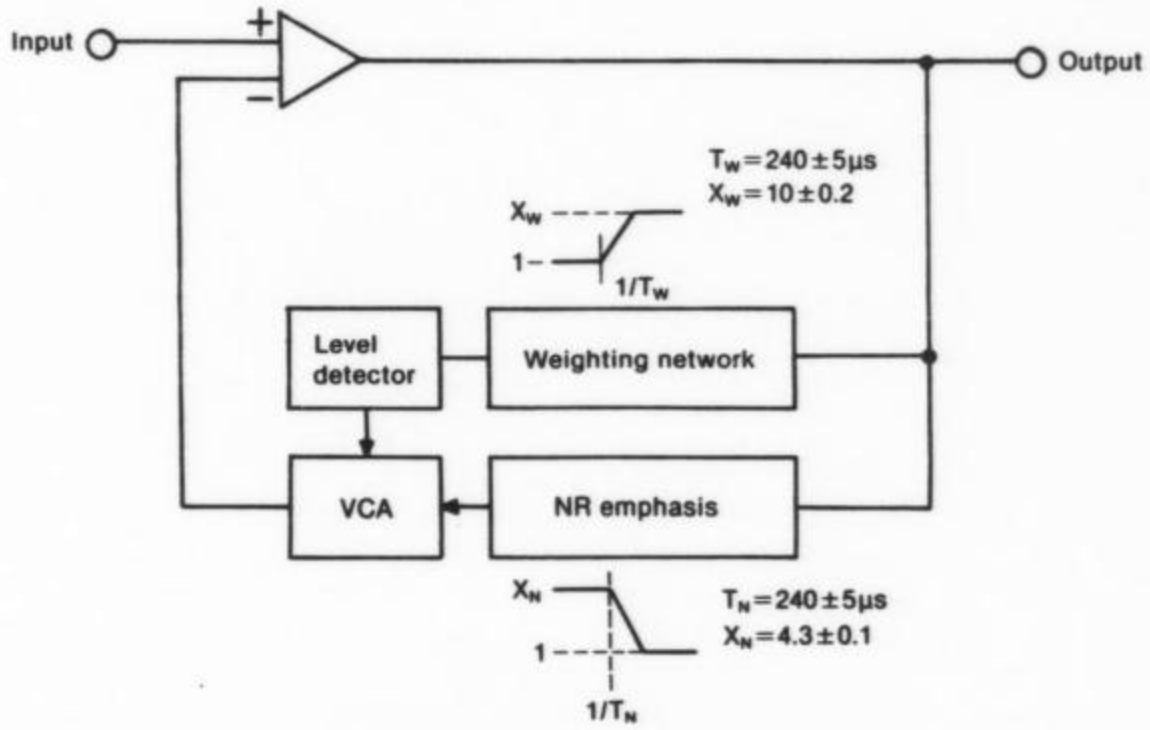
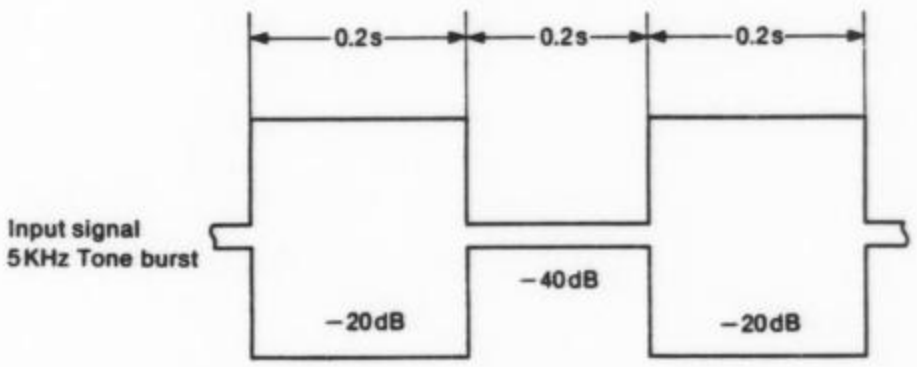


Fig. 14
Noise Reduction Circuit for AFM Signals

Note: VCA is voltage controlled amplifier.



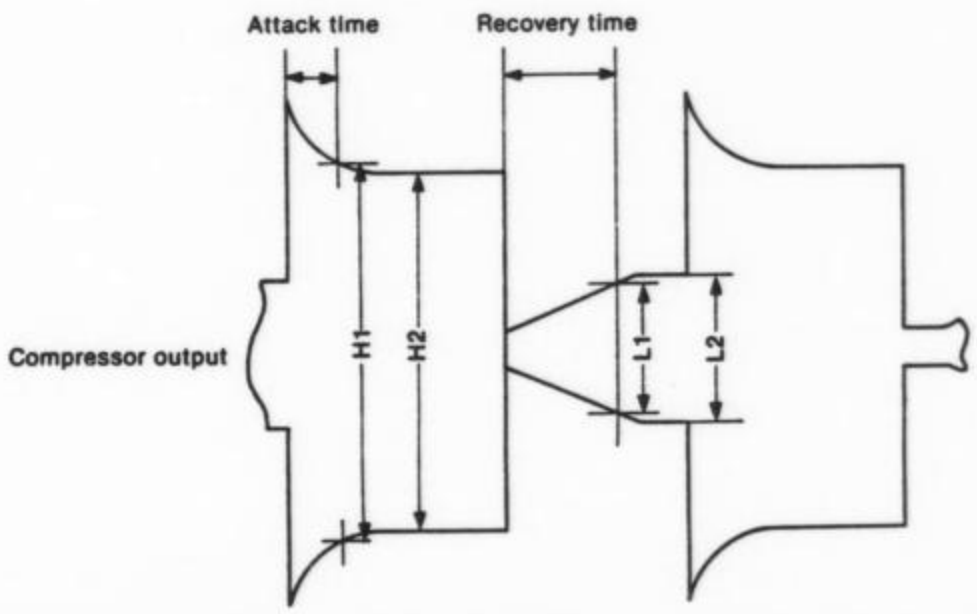
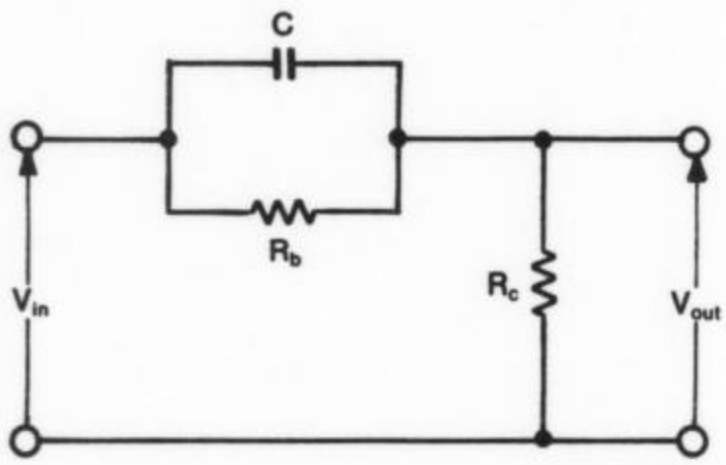


Fig. 15
Transient Response of Compressor for AFM Noise Reduction

Notes: 1. 0 dB is input level corresponding to reference level.
2. $H_1 = H_2 + 2$dB. $L_1 = L_2 - 2$ dB.



$$T_D = CR_b = 56.0\ \mu s$$

$$X_D = \frac{R_b}{R_C} = 1.80$$

$$\frac{V_{out}}{V_{in}} = \frac{1 + j\omega T_D}{1 + X_D + j\omega T_D}$$

Fig. 16
Audio Preemphasis Network

Note: Input source impedance = 0; output load impedance = ∞.

7. Tracking Control Signal Recording

7.1 Waveform and Level. The recording waveform and level shall be a series of constant flux levels alternating in polarity at a field rate and completing one cycle per frame on the longitudinal track identified as shown in Fig. 17.

7.2 Polarity of Remanent Magnetization. During the time interval that video channel 1 is recording, the polarity of the tracking-control record flux shall be such that the S pole of the magnetic domain represents the direction of the tape travel.

7.3 Timing and Period. The polarity of the flux described in 7.2 shall change to the opposite polarity when the recording of the next field is started by the channel 2 video heads. This opposite polarity interval shall continue until the beginning of the subsequent field recorded by the channel 1 video heads as shown in Fig. 17.

7.4 Optional Framing Information. If implemented, the color framing information shall be carried out by changing the timing of the polarity transition of the control signal recording as shown in Fig. 18.

7.5 Magnetization Level. The magnitude of the tracking control recorded flux shall be at least 30 dB above the residual flux of any previous recordings.

7.6 Rise Time. The rise time shall be the value shown in Fig. 17.

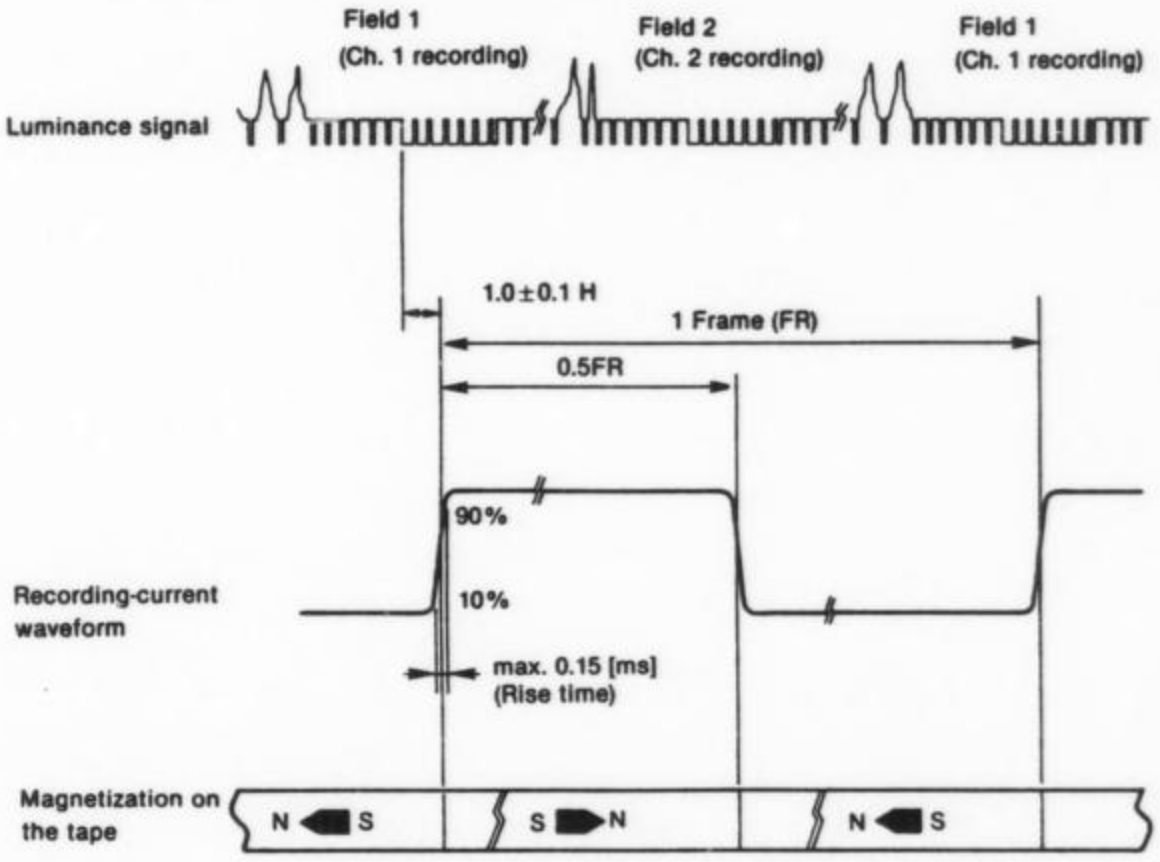


Fig. 17
Control Track Signal Waveforms and Timing for Component Signal

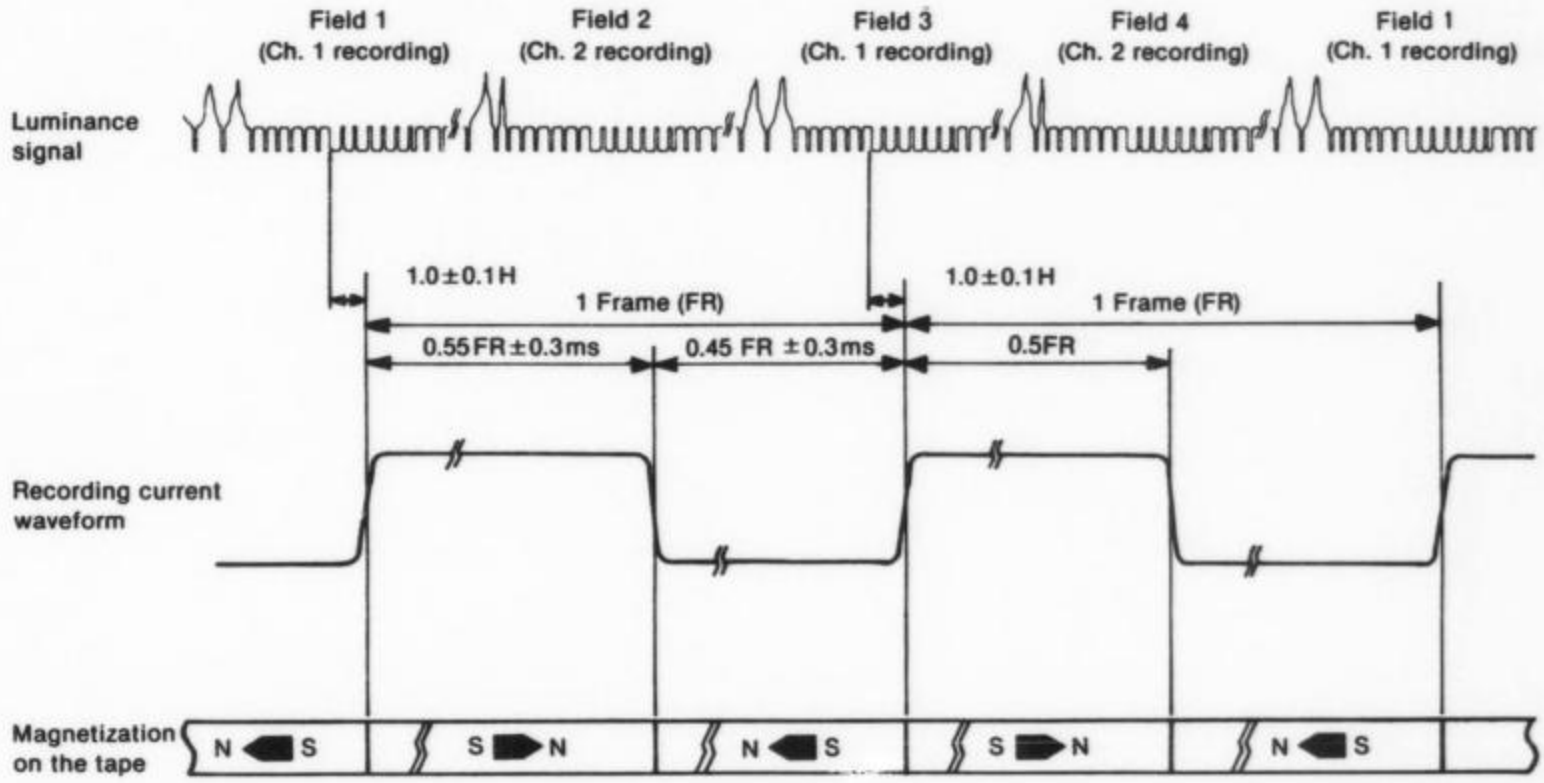


Fig. 18
Waveforms and Timing of Control Track Signal with Color Framing Information

Proposed American National Standard

for television analog recording—

½-in type M-2—
pulse code modulation audio

SMPTE 252

1. Scope

This standard specifies the pulse code modulation (PCM) audio mode of encoding and recording system utilizing a ½-in type M-2 helical-scan video tape recorder operating with video signals having a typical scanning structure of 525 lines, 59.94 fields/sec, 2:1 interlace, and the cassettes specified in SMPTE 250M.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

SMPTE 249M, Television Analog Recording — ½-in Type M-2 — Records

SMPTE 250M, Television Analog Recording — ½-in Type M-2 — Tapes and Cassettes

SMPTE 251M, Television Analog Recording — ½-in Type M-2 — Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

SMPTE RP 155, Audio Levels and Indicators for Digital Audio Records on Digital Television Ta Recorders

SMPTE RP 158, Basic System and Transp Geometry Parameters for ½-in Type M-2 Form

3. Recording Location

The PCM audio signal is recorded on tape regi PD, PE, and PF, located on the video track shown in SMPTE 249M. Since the recording a for longitudinal audio CH1 is allocated for PCM recording, longitudinal audio recording be accomplished only on one channel (CH2).

4. Audio Signal Recording

The recording of PCM audio signals in each two channels is accomplished by using the lu nance and chrominance heads provided for vi signal recording as shown in Fig. 1.

The recording is accomplished beyond the ov lap area on the tape produced by making wrap angle on the scanner more than 180°. rect recording of time compressed digital mo lation is employed.

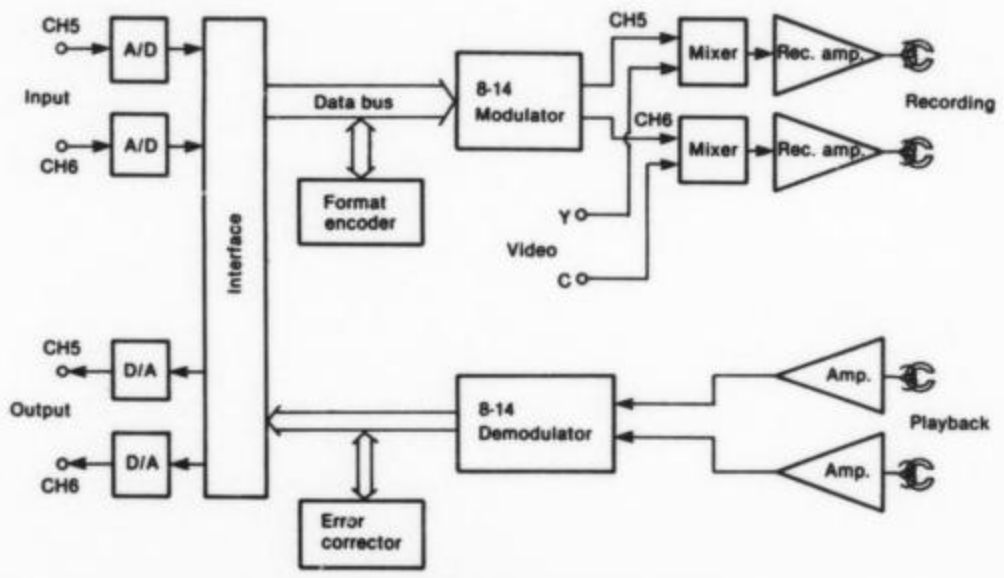


Fig. 1
Block Diagram of PCM Audio Recording System

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4.1 Source Coding. The source data consists of the audio data and the ID (identification) data.

4.1.1 Audio Data Specifications

Number of channels	Two channels (CH5 and CH6).
Reference level	The input required to give — 20 dB full-scale at A/D converter (at 1 kHz) shall be the reference level and its digital value shall be as specified in SMPTE RP 155.
Track allocation	CH5 shall be recorded by the luminance head. CH6 shall be recorded by the chrominance head.
Stereo mode	CH5 is the left channel. CH6 is the right channel.

4.1.2 Audio Data Coding

Sampling frequency	48 kHz (synchronous with video signal).
Sampling order	CH5, CH6 simultaneous.
Quantization	16-bit linear.
Coding	Two's complement binary code.

4.1.3 ID Data Coding

Data capacity	6-byte or 8-byte/field as shown in Tables 1 and 2.
Coding	NRZ

4.1.4 Source Data Arrangement. The source data arrangement within one audio field period is shown by Tables 1 and 2. The 16-bit audio samples shown in Tables 1 and 2 are each divided into upper and lower 8-bit samples which are arranged in an order starting from suffix 0. However, in this five audio field periodic sequence, the data D 800U and D 800L are available in the audio fields 0, 1, 2, and 3, but the data in audio field 4 shall be replaced by ID6 and ID7.

Table 1
Source Data Arrangement for Fields 0, 1, 2 and 3

BLOCK NUMBER	#0	#1	#2	#3	#4	#31	#32	#33	#34	#35	#63	#64	#65	#66
	D 0U	D 2U	D 4U	D 6U	D 8U	D 62U	D 64U	D 66U	D 1U	D 3U	D 59U	D 61U	D 63U	D 65U
	D 0L	D 2L	D 4L	D 6L	D 8L	D 62L	D 64L	D 66L	D 1L	D 3L	D 59L	D 61L	D 63L	D 65L
	D 67U	D 69U	D 71U	D 73U	D 75U	D 129U	D 131U	D 133U	D 68U	D 70U	D 126U	D 128U	D 130U	D 132U
DATA SYMBOL														
	D 737U	D 739U	D 741U	D 743U	D 745U	D 799U	ID 0	ID 4	D 738U	D 740U	D 796U	D 798U	D 800U	ID 2
	D 737L	D 737L	D 741L	D 743L	D 745L	D 799L	ID 1	ID 5	D 736L	D 740L	D 796L	D 798L	D 800L	ID 3

Note: U stands for the upper 8 bits, and L for the lower 8 bits.

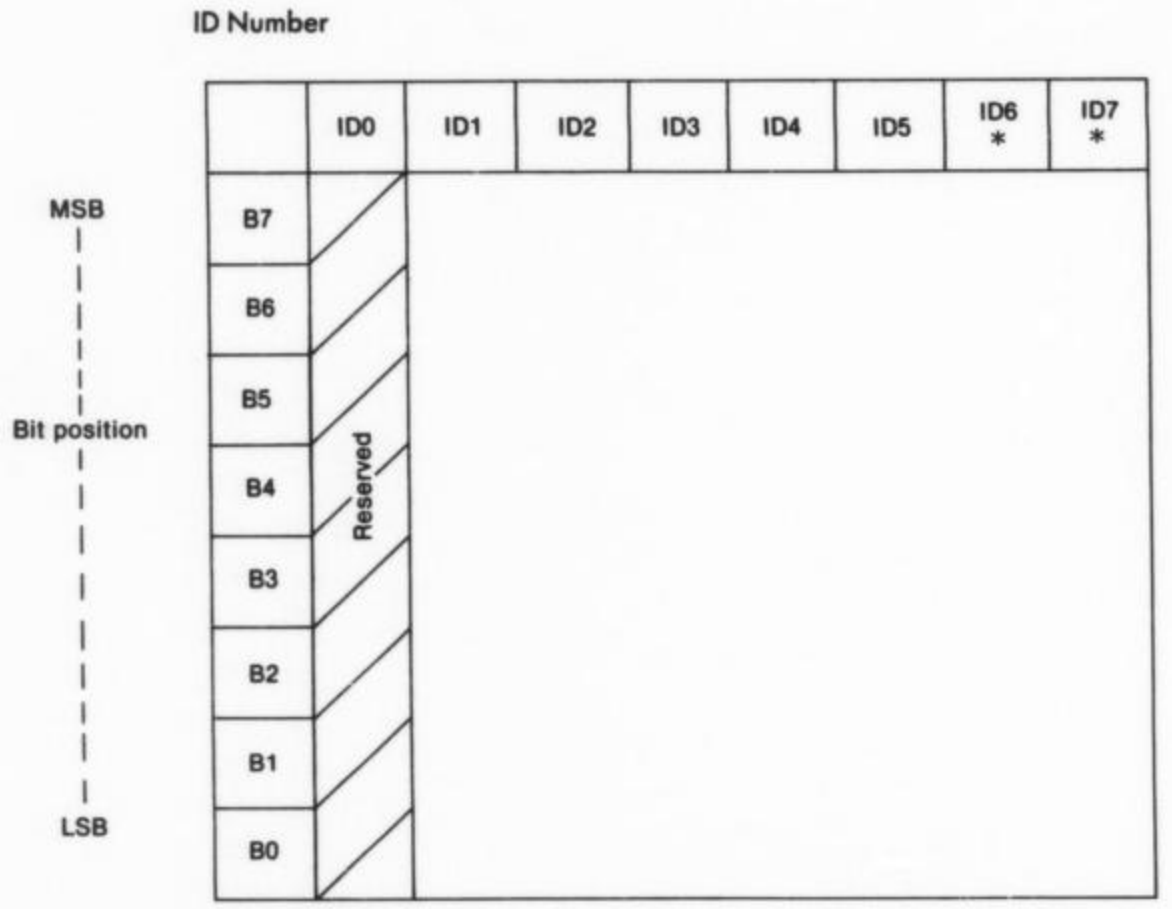
Table 2
Source Data Arrangement for Field 4

BLOCK NUMBER	#0	#1	#2	#3	#4	#31	#32	#33	#34	#35	#63	#64	#65	#66
	D 0U	D 2U	D 4U	D 6U	D 8U	D 62U	D 64U	D 66U	D 1U	D 3U	D 59U	D 61U	D 63U	D 65U
	D 0L	D 2L	D 4L	D 6L	D 8L	D 62L	D 64L	D 66L	D 1L	D 3L	D 59L	D 61L	D 63L	D 65L
	D 67U	D 69U	D 71U	D 73U	D 75U	D 129U	D 131U	D 133U	D 68U	D 70U	D 126U	D 128U	D 130U	D 132U
DATA SYMBOL														
	D 737U	D 739U	D 741U	D 743U	D 745U	D 799U	ID 0	ID 4	D 738U	D 740U	D 796U	D 798U	ID 6	ID 2
	D 737L	D 737L	D 741L	D 743L	D 745L	D 799L	ID 1	ID 5	D 736L	D 740L	D 796L	D 798L	ID 7	ID 3

Note: U stands for the upper 8 bits, and L for the lower 8 bits.

4.1.5 ID Data Specification. The ID data region is available for the user, and its contents are shown in Fig. 2 and Tables 1 and 2.

4.2 Signal Processing. The 800 or 801 audio data samples per field are divided into 67 blocks, and the block sync signal (SYNC), block address signal (ADDRESS), block address error detecting code (CRCC), and the error correction code (ECC2 and ECC1) are added to each block. The signal format is shown in Fig. 3 where the recording order for each data sample is MSB first.



Reserved Region:

Field Address	B_0	B_1	B_2	B_3	B_4	B_5	B_6	B_7
0	0	0	0					
1	1	0	0					
2	0	1	0		Not specified			
3	1	1	0					
4	0	0	1					

Fig. 2
ID Data Content and Reserved Region for Field Address

Note: Not available in fields 0, 1, 2, 3

Block Address →

Recording Direction ↓

SYNC	SYNC	SYNC	SYNC		SYNC	SYNC		SYNC	SYNC
ADDRESS	ADR0	ADR1	ADR2		ADR33	ADR34		ADR65	ADR66
CRCC	CRCC	CRCC	CRCC		CRCC	CRCC		CRCC	CRCC
DATA	D 0U	D 2U	D 4U		D 66U	D 1U		D 63U	D 65U
	D 0L	D 2L	D 4L		D 66L	D 1L		D 63L	D 65L
	D 67U	D 69U	D 71U		D 133U	D 66U		D 130U	D 132U
	D 737U	D 739U	D 741U		ID 4	D 738U		*	ID 2
	D 737L	D 739L	D 741L		ID 5	D 738L		**	ID 3
ECC2	ECC2 0	ECC2 1	ECC2 2		ECC2 33	ECC2 34		ECC2 65	ECC2 66
ECC1	ECC1 0	ECC1 1	ECC1 2		ECC1 33	ECC1 34		ECC1 65	ECC1 66

*ID 6 or D 800U
**ID 7 or D 800L

Fig. 3
PCM Signal Format

4.2.1 PCM Signal Construction. The PCM signal construction is shown in Fig. 4.

Preamble area — Length: One horizontal line (63.5 μsec)

Content: A single frequency signal of 5.0625 MHz (basic)

Phase continuity to the beginning of the sync block shall be established.

Postamble area — Length: One horizontal line (63.5 μsec)

Content: A single frequency signal of 5.0625 MHz (basic)

Phase continuity to the end of the data block shall be established.

(Note: A basic dimension is a fundamental dimension to which no tolerance is applicable.)

SYNC: Specified in 4.2.4.

ADDRESS: Started from "00" by the sequential address for the identification of each of the 67 blocks.

CRCC: CRCC is used for block ADDRESS error detection; this detected error pointer is referred to data error correction. The error detection method is based upon a CRC code containing 8 bits and its generator polynominal G1(x) is as follows:

$G1(x) = X^8 + 1$ (preset all "1")

DATA: Data shall be arranged in the order shown in Tables 1 and 2 and Fig. 3.

ECC2, ECC1: Specified in 4.2.2.

Transmission data rate: 11.57 Mbps per channel.

4.2.2 Error Correction Codes. The error detection and correction system (ECC) shall be based on the Reed-Solomon code which contains the elements of Galois Field 2^8, and its generator polynominal G2(x) and primitive polynominal G3(x) are given by:

$$G2(x) = \prod_{i=0}^{3} (x - \alpha^i)$$

$$G3(x) = X^8 + X^4 + X^3 + X^2 + 1$$

The generation scheme of error correction codes ECC1 and ECC2 is shown in Fig. 5.

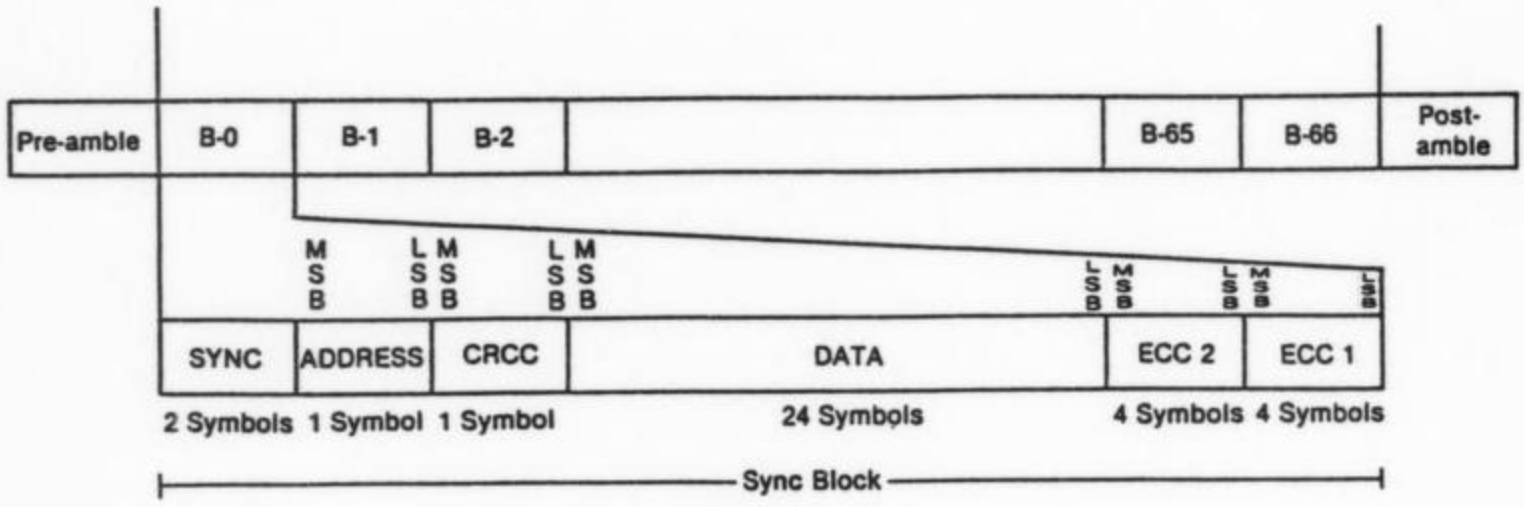
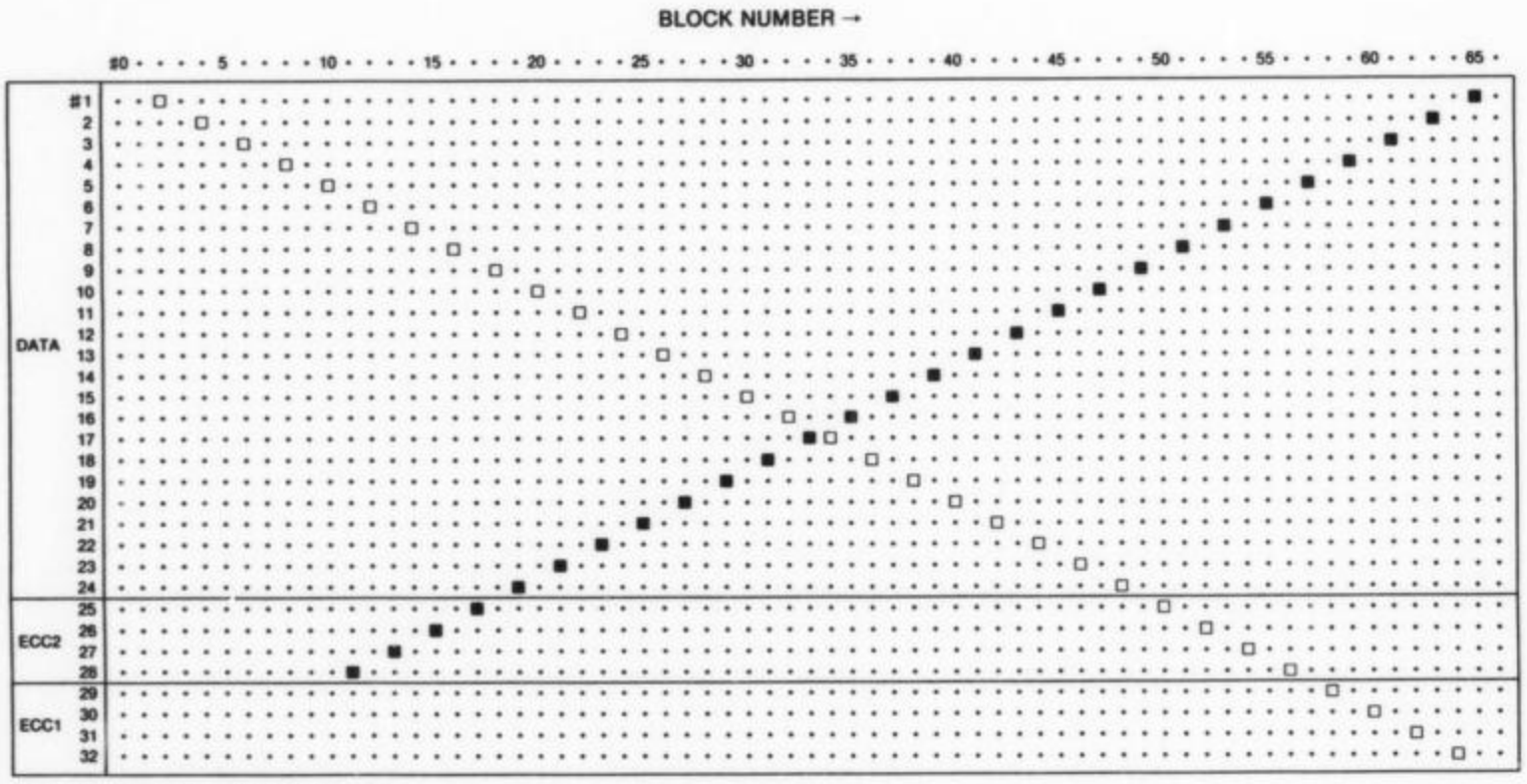


Fig. 4
PCM Signal Construction

Note: 1 symbol = 8 bits.

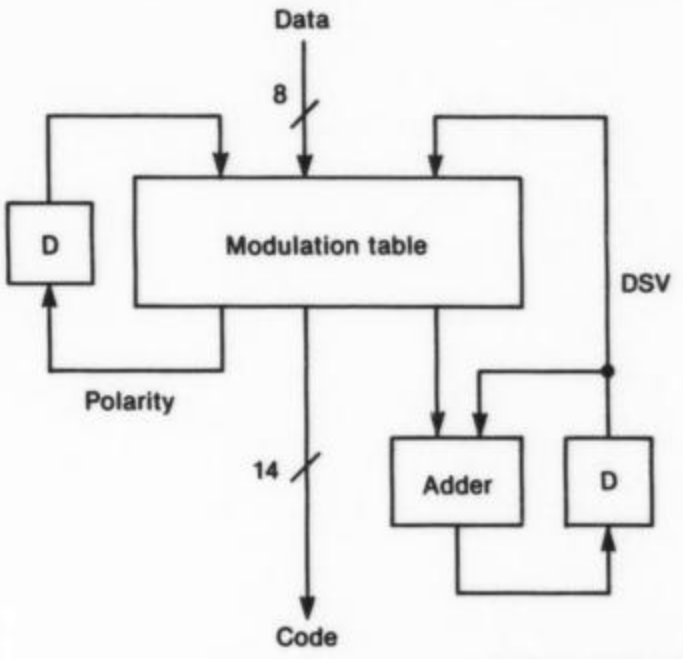


Note: ECC1; GF (2^8), (32, 28, 5)..... □
ECC2; GF (2^8), (28, 24, 5)..... ■

Fig. 5
Error Correction Format

Note: ECC1: GF(2^8), (32, 28, 5) ..... □
ECC2: GF(2^8), (28, 24, 5) ..... ■

4.2.3 Channel Coding. The channel code shall conform to the 8-14 modulation method. (See Fig. 6 and Tables 3 and 5.) This method is based on an algorithm where the DC component is minimized when the 8-bit data is converted to a 14-bit code. The data converted by the 8-14 modulation method shall be further transformed by NRZI conversion process before it is recorded.



D: One symbol delay

Fig. 6
Block Diagram for 8-14 Modulation

Table 3
Selection of Modulation Code

Preceding DSV	Preceding Polarity	Selection of Modulation Code
Positive Polarity	Positive	Select group A
	Negative	Select group B
Zero	—	Select small absolute value of CDS
Negative Polarity	Positive	Select group B
	Negative	Select group A

Notes: 1. DSV. DSV is an abbreviation for digital sum value and indicates the integral value which is counted from the beginning of the NRZI-modulated waveform, taking high level = 1 and low level = —1.

2. CDS. CDS is an abbreviation for code word digital sum and indicates the DSV of one symbol modulation code where NRZI modulation starts from the low level.

3. Polarity. Positive polarity indicates a high level of the NRZI modulated waveform. Negative polarity indicates a low level of the NRZI-modulated waveform.

4.2.4 Sync Pattern. The sync pattern shall be constructed as shown in Fig. 7.

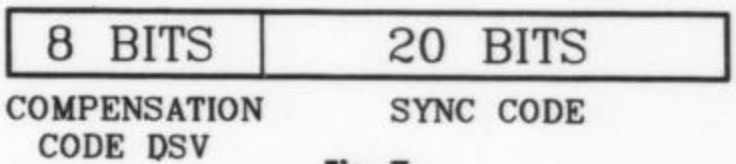


Fig. 7
Sync Pattern

The sync code shall be defined as follows:

00100000001000000010

Compensation code DSV shall be chosen in such a way as to compensate the DC component of the last block. Table 4 shows this compensation code.

Table 4
Compensation Code

DSV	Polarity	
	Positive	Negative
— 4	00101000	01000001
— 2	01010001	00100001
0	00001000	00001000
2	00100001	01010001
4	01000001	00101000

4.2.5 Record Physical Offset. The physical offset between the two PCM audio channels shall be as shown in Fig. 8 due to the Y/C head offset as shown in Table 2 of SMPTE 249M.

4.2.6 Recording Video and Audio Timing. The recording timing between video and audio signals shall be as shown in Fig. 9.

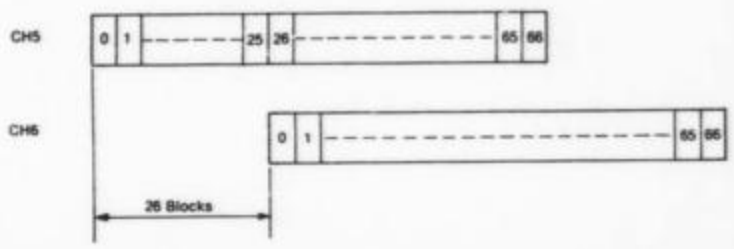


Fig. 8
Physical Offset Between Two Audio Channels

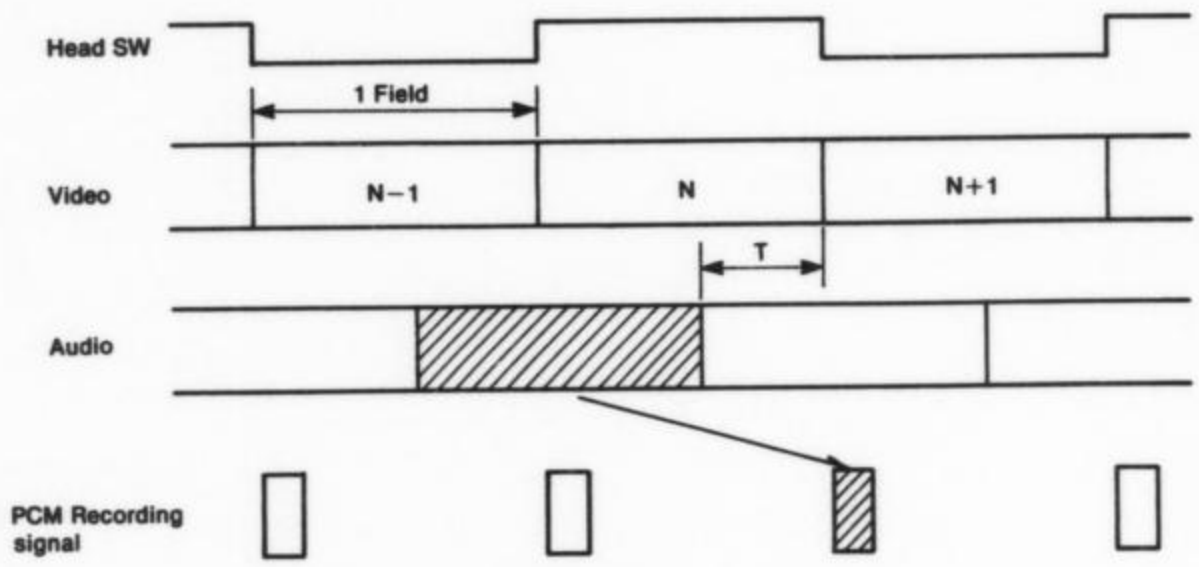


Fig. 9
Recording Video and Audio Timing

Note: T = 3.0 ± 0.2 ms.

Table 5
8-14 Modulation

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
00	01001010101010	0	01001010101010	0
01	01010100101010	0	01010100101010	0
02	01010101010010	0	01010101010010	0
03	10010010101010	0	10010010101010	0
04	10010101001010	0	10010101001010	0
05	10010101010100	0	10010101010100	0
06	10100100101010	0	10100100101010	0
07	10100101010010	0	10100101010010	0
08	10101001001010	0	10101001001010	0
09	10101001010100	0	10101001010100	0
0A	10101010010010	0	10101010010010	0
0B	10101010100100	0	10101010100100	0
0C	01001001010010	0	01001001010010	0
0D	01010010010010	0	01010010010010	0
0E	01010010100100	0	01010010100100	0
0F	01001001000100	0	01001001000100	0
10	10001000100100	0	10001000100100	0
11	10001001001000	0	10001001001000	0
12	10010001000100	0	10010001000100	0
13	10010010001000	0	10010010001000	0
14	01001000101010	0	01001000101010	0
15	01001010100010	0	01001010100010	0
16	01010001001010	0	01010001001010	0
17	01010001010100	0	01010001010100	0
18	01010100100010	0	01010100100010	0
19	01010101000100	0	01010101000100	0
1A	10010001010010	0	10010001010010	0
1B	10010010100010	0	10010010100010	0
1C	10100010010010	0	10100010010010	0
1D	10100010100100	0	10100010100100	0
1E	10100100100010	0	10100100100010	0
1F	10100101000100	0	10100101000100	0
20	01000100010010	0	01000100010010	0
21	01000100100100	0	01000100100100	0
22	01000101001000	0	01000101001000	0
23	01001000100010	0	01001000100010	0
24	01001010001000	0	01001010001000	0
25	01010010000100	0	01010010000100	0
26	10000100010100	0	10000100010100	0
27	10000100101000	0	10000100101000	0
28	10001000010010	0	10001000010010	0
29	10001010010000	0	10001010010000	0
2A	10010000100010	0	10010000100010	0
2B	10010100010000	0	10010100010000	0
2C	10100010000100	0	10100010000100	0
2D	10100100001000	0	10100100001000	0

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
2E	10010000101010	0	10010000101010	0
2F	10010101000010	0	10010101000010	0
30	10100001001010	0	10100001001010	0
31	10100001010100	0	10100001010100	0
32	10101001000010	0	10101001000010	0
33	10101010000100	0	10101010000100	0
34	01000010001010	0	01000010001010	0
35	01000010010100	0	01000010010100	0
36	01000010101000	0	01000010101000	0
37	01010001000010	0	01010001000010	0
38	01010100001000	0	01010100001000	0
39	10000100001010	0	10000100001010	0
3A	10000101010000	0	10000101010000	0
3B	10100001000010	0	10100001000010	0
3C	10101000010000	0	10101000010000	0
3D	01000100000100	0	01000100000100	
3E	01001000001000	0	01001000001000	0
3F	01000010000010	0	01000010000010	0
40	01010000010000	0	01010000010000	0
41	10001000000100	0	10001000000100	0
42	10010000001000	0	10010000001000	0
43	10000100000010	0	10000100000010	0
44	10100000010000	0	10100000010000	0
45	01001001010100	2	00010100100100	−4
46	01001010100100	2	00100100010100	−4
47	01010100100100	2	00101000100100	−4
48	10001001010010	2	01001000101000	−4
49	10010010010010	2	01010010010000	−4
4A	10000100100010	4	00010101010010	−2
4B	00100010010000	4	00101010100010	−2
4C	10000010000100	4	01010010100010	−2
4D	01010100001010	4	00001000101010	−2
4E	10000101010010	4	00010001010100	−2
4F	10100101010000	4	00010101000100	−2
50	10100100010010	2	00001010010010	−4
51	10100101001000	2	00100100001010	−4
52	10000100010010	2	00101000010010	−4
53	00010001001000	2	01001001010000	−4
54	00100100010000	2	10010000101000	−4
55	10101000101010	2	10100001001000	−4
56	01000101000010	4	00101000100010	−2
57	10000101000100	4	01000100010100	−2
58	10001010000100	4	01001000010010	−2
59	00100010101010	2	00001010000100	−4
5A	00010001010000	4	01010001000100	−2
5B	01000010001000	4	10001000101000	−2
5C	00101010001010	2	01001000001010	−4

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
5D	01000100101010	2	10010000010100	−4
5E	01000001010010	4	10010010010000	−2
5F	10000001001010	4	00001000100010	−2
60	10010010000010	4	00010010000100	−2
61	01010010001010	2	00010010000010	−4
62	00010000010100	4	00010000010000	−2
63	01000001000100	4	01010000101010	−2
64	01010100010010	2	10010000001010	−4
65	10001010100010	2	00100100000010	−4
66	10010100100010	2	01001000000010	−4
67	10100010001010	2	10010000000010	−4
68	10100010101000	2	00010100010100	−6
69	10101010001000	2	00101000101000	−6
6A	10001010001010	6	10100101000010	−2
6B	01000100100010	2	00001010010100	−6
6C	10000010001010	2	00010100001010	−6
6D	10001000100010	2	00101000010100	−6
6E	10010010000100	2	01010000101000	−6
6F	00010000100100	2	10100001010000	−6
70	10001010101000	6	01000100001010	−2
71	10010100101000	6	01010000100010	−2
72	10000010001000	6	10001001010000	−2
73	10000101010100	6	10100001000100	−2
74	10010101010000	6	00010001000010	−2
75	10101001010000	6	00100100000100	−2
76	00100001010000	6	10101010000010	−2
77	00100001000100	2	01010000010100	−6
78	01000010010000	6	10001000001010	−2
79	01001000010000	2	00001010000010	−6
7A	10101000001010	6	00101000001000	−2
7B	10001000001000	2	01010000001010	−6
7C	00100101000010	2	00010100000010	−6
7D	00100000101000	6	01010000001000	−2
7E	01000010010010	2	10100000001010	−6
7F	10000000100010	6	10001000000010	−2
80	01001001000010	2	01010000000010	−6
81	01000010100100	2	00101000000010	−6
82	01000001001000	6	10010000000100	−2
83	10001010000010	6	01000100000010	−2
84	00100001010010	2	10100000010100	−6
85	10000010100010	6	01001000000100	−2
86	10000010101010	6	00100010000010	−2
87	10000001000100	6	10100000100010	−2
88	01000100001000	2	10100000101000	−6
89	00010010010000	2	00101000001010	−6
8A	10000101000010	6	10100000101010	−2
8B	10101000010100	6	00010100001000	−2

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
8C	10010100001010	6	00001010001000	−2
8D	10000101001010	6	10010000010010	−2
8E	10101000101000	6	10001000010100	−2
8F	10010100010100	6	01000101010000	−2
90	10001010010100	6	00001010100010	−2
91	00001000101000	2	01010001010000	−6
92	10001010001000	2	00101001010000	−6
93	10000100100100	2	00010101010000	−6
94	01000101000100	2	00001010101000	−6
95	00100010100010	2	00001010001010	−6
96	10000100010000	6	10100001010010	−2
97	10101000100010	2	00010100101000	−6
98	10100010010100	2	10100000000100	−4
99	10010101000100	2	01010000000100	−4
9A	10010001010100	2	00101000000100	−4
9B	10001000101010	2	10100000010010	−4
9C	10000000010000	4	01010101000010	−2
9D	00100000010010	4	00001010101010	−2
9E	01010010101000	2	00010100000100	−4
9F	10010100000100	4	00001000001000	−2
A0	10000010100100	4	00001001000100	−2
A1	01001010000010	4	10100010001000	−2
A2	01000101010010	2	10100000100100	−4
A3	00101010101000	2	01010000010010	−4
A4	10000001000010	4	10010000100100	−2
A5	00100000100100	4	01010100010000	−2
A6	00010000101000	4	01001010010000	−2
A7	10101010100010	2	00001001000010	−4
A8	10001001000010	4	01000100101000	−2
A9	10000010010010	4	00101010001000	−2
AA	01000010100010	4	00100010101000	−2
AB	10001010101010	2	10010001010000	−4
AC	00100010001000	2	01010000100100	−4
AD	10001001000100	2	01001000010100	−4
AE	10101001000100	2	00100101010000	−4
AF	10100100100100	2	00001010100100	−4
B0	10101000010010	4	00100010001010	−2
B1	10100100001010	4	00010100100010	−2
B2	01010101010000	4	00001001010010	−2
B3	01000010101010	4	10100010100010	−2
B4	01000100010000	4	01010001010010	−2
B5	00100001001000	4	00101000101010	−2
B6	10010010100100	2	10100010010000	−4
B7	10010001001010	2	01010001001000	−4
B8	01010101001000	2	00101010010000	−4
B9	01010010010100	2	00100100101000	−4
BA	01001010010010	2	00010101001000	−4

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
BB	01001001001010	2	00010100010010	−4
BC	00101010010100	2	00010010101000	−4
BD	00100101010100	2	00010010001010	−4
BE	00100101001010	2	00001001010100	−4
BF	10101001010010	2	00001001001010	−4
C0	10101010010000	4	00010100101010	−2
C1	10101000100100	4	10101010101000	−2
C2	10100100101000	4	10101010001010	−2
C3	10100100010100	4	10100010101010	−2
C4	10010100010010	4	10100100010000	−2
C5	10010010101000	4	10010001001000	−2
C6	10010010001010	4	01010010001000	−2
C7	10001010100100	4	01001001001000	−2
C8	10001010010010	4	01001000100100	−2
C9	10000100101010	4	00101001000100	−2
CA	01010100101000	4	00100101001000	−2
CB	01010100010100	4	00100100010010	−2
CC	01001010101000	4	00100010010100	−2
CD	01001010001010	4	00010010100100	−2
CE	01000101010100	4	00010010010010	−2
CF	01000101001010	4	00010001001010	−2
D0	10001000010000	4	00101001010010	−2
D1	10000100001000	4	10101010010100	−2
D2	10010101010010	2	00101001001000	−4
D3	10010100101010	2	00010010010100	−4
D4	10101001001000	4	10100101010100	−2
D5	10010101001000	4	10100101001010	−2
D6	10010100100100	4	01010101010100	−2
D7	10010010010100	4	01010101001010	−2
D8	10001001010100	4	01010010101010	−2
D9	10001001001010	4	00101010101010	−2
DA	01001010010100	4	00100100100100	−2
DB	10101010101010	2	00001000010000	−4
DC	00100000010000	0	00100000010000	0
DD	00001000000100	0	00001000000100	0
DE	00010000001000	0	00010000001000	0
DF	00101000010000	0	00101000010000	0
E0	00100001000010	0	00100001000010	0
E1	00001010010000	0	00001010010000	0
E2	00101010000100	0	00101010000100	0
E3	00101001000010	0	00101001000010	0
E4	00100001010100	0	00100001010100	0
E5	00010101000010	0	00010101000010	0
E6	00010000101010	0	00010000101010	0
E7	00100100001000	0	00100100001000	0
E8	00100010000100	0	00100010000100	0
E9	00010100010000	0	00010100010000	0

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
EA	00010000100010	0	00010000100010	0
EB	00001001001000	0	00001001001000	0
EC	00001000010010	0	00001000010010	0
ED	00100101000100	0	00100101000100	0
EE	00100100100010	0	00100100100010	0
EF	00100010100100	0	00100010100100	0
F0	00100001001010	0	00100001001010	0
F1	00010010100010	0	00010010100010	0
F2	00010001010010	0	00010001010010	0
F3	00010101010100	0	00010101010100	0
F4	00010101001010	0	00010101001010	0
F5	00010010001000	0	00010010001000	0
F6	00010001000100	0	00010001000100	0
F7	00001000100100	0	00001000100100	0
F8	00100010010010	0	00100010010010	0
F9	00101010100100	0	00101010100100	0
FA	00101010010010	0	00101010010010	0
FB	00101001010100	0	00101001010100	0
FC	00101001001010	0	00101001001010	0
FD	00100101010010	0	00100101010010	0
FE	00100100101010	0	00100100101010	0
FF	00010010101010	0	00010010101010	0

PROPOSED

SMPTE RECOMMENDED PRACTICE — RP 158

Basic System and Transport Geometry Parameters for ½-in Type M-2 Format

1. *Scope*

This practice specifies the video recording system, scanner parameters, and test conditions for ½-in type M-2 helical-scan video tape recorders operating with video signals having a typical scanning structure of 525 lines, 59.94 fields/sec, 2:1 interlace, and utilizing the cassettes specified in SMPTE 250M. The parameters described in this practice are for reference purposes only and should not be taken as the only method available to attain the specifications as defined in SMPTE 249M.

2. *Referenced Documents*

This practice is intended for use in conjunction with the following documents:

SMPTE 249M, Television Analog Recording—½-in Type M-2—Records

SMPTE 250M, Television Analog Recording—½-in Type M-2—Tapes and Cassettes

SMPTE 251M, Television Analog Recording—½-in Type M-2—Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

SMPTE 252M, Television Analog Recording—½-in Type M-2—Pulse Code Modulation Audio

3. *Definitions*

Scanner: A mechanical assembly containing a drum, rotating pole tips, and tape-guiding elements used to record and reproduce video and PCM audio mode signals.

Drum: A cylindrical column around which the tape is at least partially wrapped in order to form the head-to-tape interface of a video tape recording system.

Upper Drum: The part of the drum which is not in contact with the reference edge of the tape. (See Fig. 1.)

Lower Drum: The part of the drum which contacts the reference edge of the tape and provides tape-guiding functions. (See Fig. 1.)

Effective Drum Diameter: The value of drum diameter which yields the actual video and PCM audio record dimensions in a theoretical calculation. This value is equal to or greater than the actual drum diameter.

Helix Angle: The angle formed between the path of the rotating pole tips and the tape reference edge guiding system.

Track Angle: The angle formed between the video record and the reference edge of the tape.

Center Span Tension: A calculated value of the tape tension at a point midway between the tape entrance and exit guides of the scanner in a video tape recording system.

Wrap Angle: The angle at the center of the drum rotation subtended by the lines of contact between the drum and the reference edge of the tape.

Lead Signal Overlap: That portion of the helical record which is required to provide a duplicate (overlap) recording.

4. *General Specifications*

4.1 Dimensions are in the metric system.

4.2 A basic dimension is a fundamental dimension to which no tolerance is applicable.

4.3 Tests and measurements made on the recorder to check the parameters specified in this standard shall be made under the following atmospheric conditions:

Temperature for drum diameter	20°C ± 0.5°C
Temperature for all other tests	20°C ± 1.0°C
Relative humidity	50% ± 2%
Barometric pressure	86 to 106 kPa
Conditioning time before testing	24 hours

5. *Tape Speed*

The tape speed shall be 67.693 mm/s, basic.

6. *Representative Scanner Parameters*

6.1 Drum Diameter and Structure. The effective drum diameter, tape tension, helix angle, and tape speed taken together completely determine the track angle. Different methods of design and/or minor variations in drum diameter and tape tension will produce equivalent recordings for interchange purposes.

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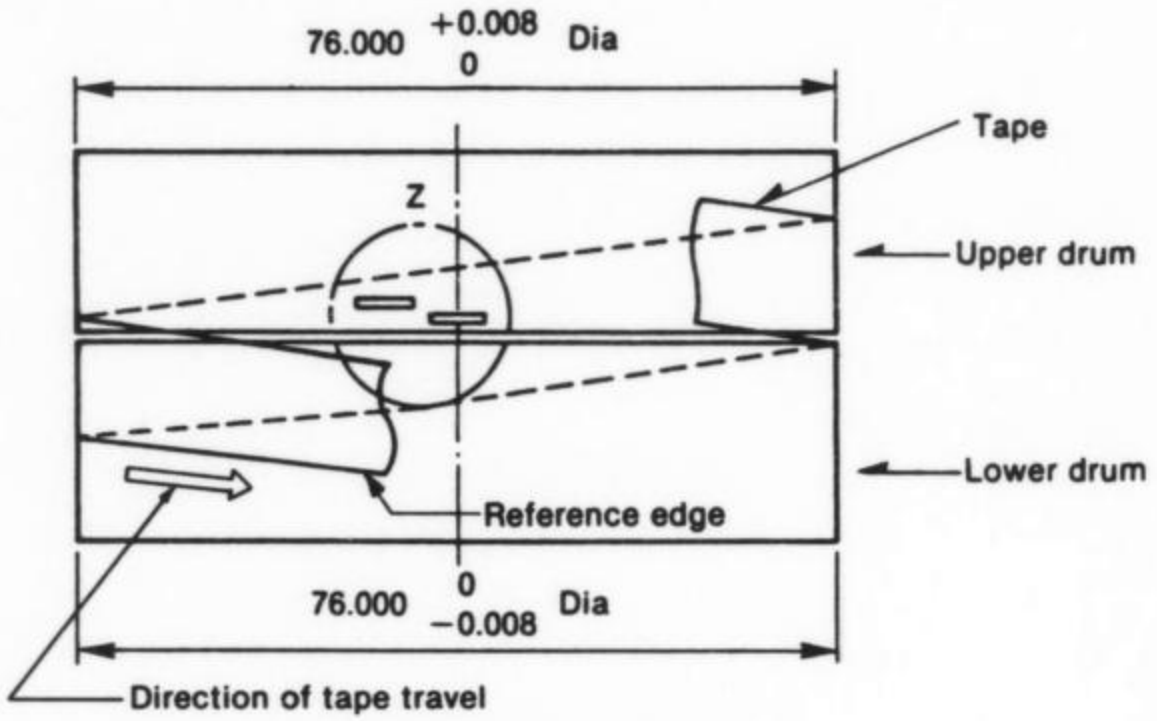
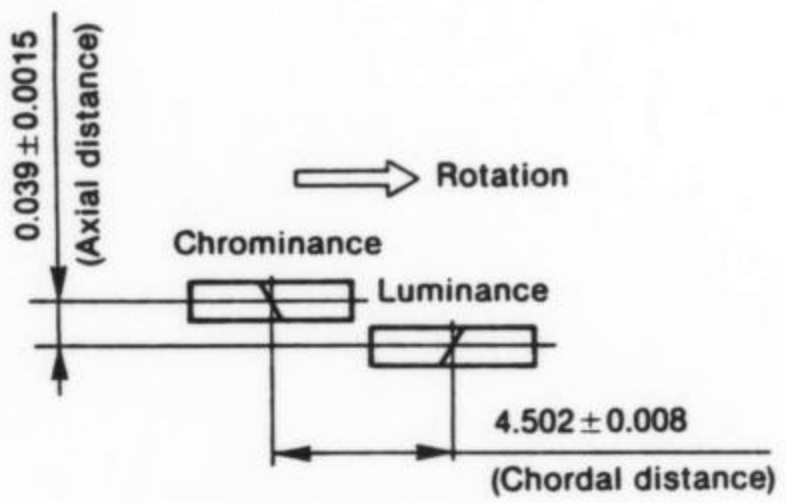


(a) Drum and Tape Wrap



(b) Details of Zone Z

Fig. 1
Side View of Chrominance and Luminance Pole Tips

6.1.1 Actual Upper Drum Diameter. The actual upper drum diameter shall be 76.000 mm + 0.008 mm — 0.000 mm.

6.1.2 Actual Lower Drum Diameter. The actual lower drum diameter shall be 76.000 mm + 0.000 mm — 0.008 mm.

6.1.3 Upper Drum Section. The upper drum section shall rotate together with the video heads.

6.1.4 Center Span Tension. The center span tension shall be 0.31 N ± 0.05 N.

6.1.5 Helix Angle. The helix angle formed by the scanner and all associated tape guides shall be 4.250° ± 0.001°.

6.2 Scanner Pole Tips. Four circumferential pole tips shall be located as shown in Fig. 2.

6.2.1 Pole Tip Projection. Each pole tip should project radially 0.035 mm (nominal value) above the upper drum surface.

6.2.2 Luminance Pole Tips. Two pole tips circumferentially arranged 180° ± 0.003° apart shall be provided for the luminance signal.

6.2.3 Chrominance Pole Tips. Each luminance pole tip shall have an associated pole tip for the time compressed chrominance signal and the FM audio signals. The chrominance pole tips shall be located at a chordal distance of 4.502 mm ± 0.008 mm in a counterrotational direction from the associated luminance pole tips, and are axially displaced from the associated luminance pole tips by 0.0390 mm ± 0.0015 mm in a direction away from the reference edge of the tape. (See Fig. 1b.)

6.2.4 Channel Identification. Suitable means, such as a pulse generator producing one pulse per drum revolution, shall be provided for identifying the one head pair which records field 1. This pair is identified as channel 1, and the other pair is identified as channel 2.

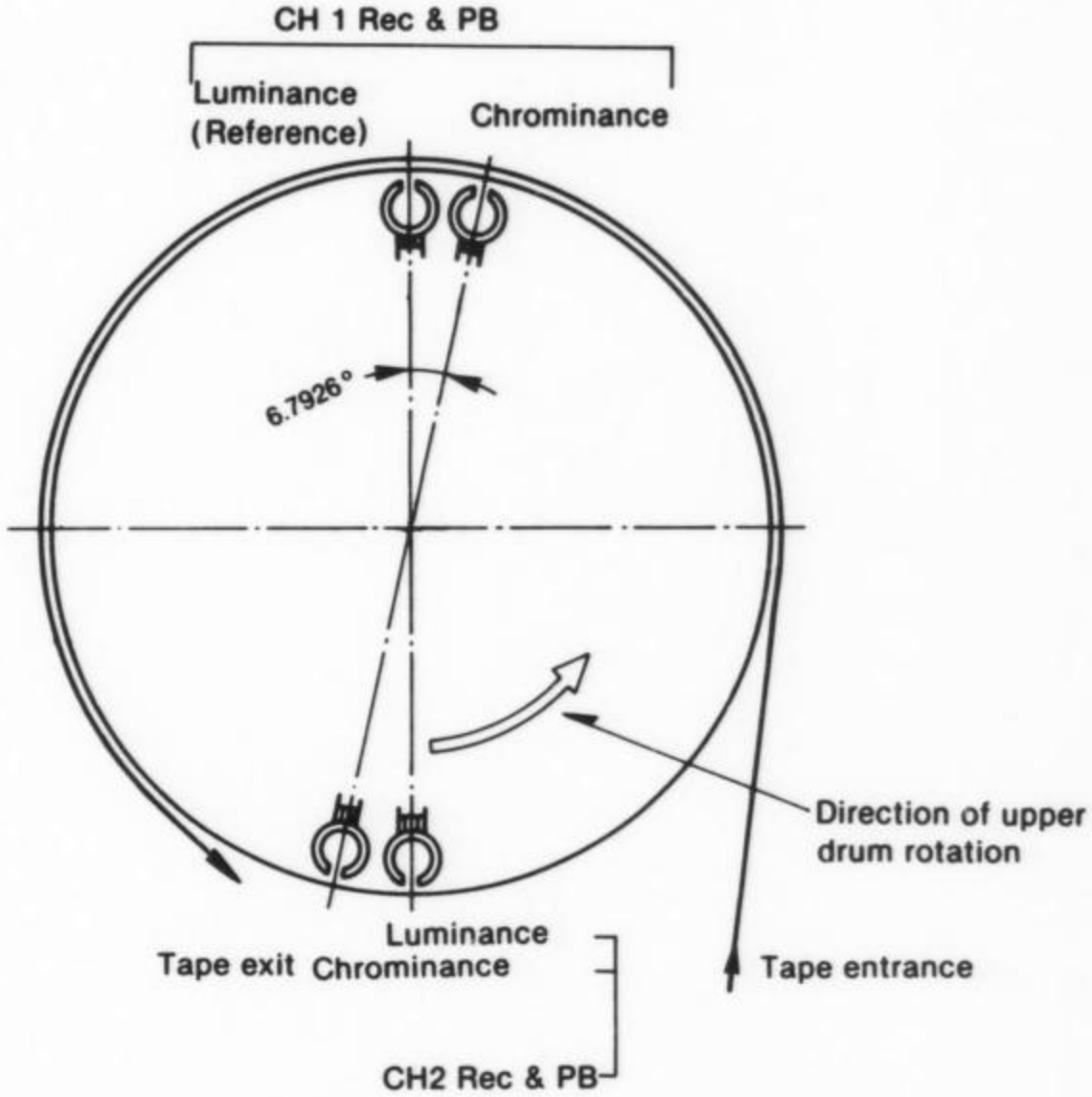


Fig. 2
Top View of Chrominance and Luminance Pole Tips

SUSTAINING MEMBERS

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Chapman/Leonard Studio Equipment
Christie Electric Corp.
Alfred Chrosziel Filmtechnik GmbH
Chyron Corp. (a member of the Chyron Group)
Cinema Products Corp.
Cinematography Electronics, Inc.
CineMills Corp.
Cipher Digital, Inc.
CMX Corp. (a member of the Chyron Group)
Coherent Communications, Inc.
Colorfilm Pty. Ltd.
Communications Engineering Inc.
Comprehensive Video Supply Corp.
Computer Prompting Corp.
Condor Broadcast Video Center
Conrac Display Products, Inc., (a Mark IV Industries Co.)
Consolidated Film Industries (CFI)
Convergence
Corporate Communications Consultants, Inc.
Cox Enterprises, Inc.
Cubicomp Corp.
Deluxe Laboratories
DeSisti Lighting/Desmar Corp.
Digital Equipment Corp.
Digital F/X, Inc.
Digital Processing Systems Inc.
Digital Video Systems Corp.
The Walt Disney Co.
Di-Tech Inc.
Dolby Laboratories, Inc.
DSC-Digital Services Corp. (a member of the Chyron Group)
Du Art Film Laboratories, Inc./Du Art Video
Dubner Computer Systems, Inc.
DYNAIR Electronics, Inc.
Dynamic Technology Ltd. (a member of the Intl. Generics Group of companies)
East Coast Video Systems (ECVC, Inc.)
Eastman Kodak Co.
ECHOlab, Inc.
Ediflex Systems
Elki International, Inc.
Evertz Microsystems Ltd.
Faroudja Laboratories, Inc.
FERCO, Inc.
Filmline Technologies
FOR-A Corp. of America
Fostex Corp. of America
Foto-Kem Industries, Inc.
FPC Inc. (a Kodak Co.)
Frezzolini Electronics Inc.
Fujinon Inc.
Fuji Photo Film U.S.A., Inc.
Fumeo S.p.A.
Adolph Gasser, Inc.
General Electric Co.
General Electronics Systems, Inc./Diaquest
Geocam Corp.
Alan Gordon Enterprises, Inc.
Graham-Patten Systems, Inc.
Grass Valley Group, Inc.
Gray Engineering Labs., Inc.
R/Greenberg Associates, Inc.
GRETAG Displays Ltd.
Guffanti Film Labs., Inc.
Harris Video Systems
HEDCO Electronic Devices Corp.
Hitachi Denshi America, Ltd.
Hollywood Film Co.
Houston Fearless 76, Inc.
Hughes Communications, Inc.
Ikegami Electronics (U.S.A.), Inc.
Image Transform, Inc.
Image Video Ltd.
Imagica Corp.
Innovative Television Equip. dba ITE
International Cinema Equip. Co.
Intertec Publishing Corp.
Irene Film Laboratories (Pty) Ltd.
J & R Film Co., Inc.
JVC Professional Products Co.
KEM Elektronik Mechanik GmbH
Laumic Co., Inc.
LEE Colortran, Inc.
Leitch Video of America, Inc.
Lexicon, Inc.
Lider Cine Laboratorios S.A.
Lightmaker, a div. of Camera Platforms Intl., Inc.
Lowel-Light Mfg., Inc.
LTM Corp. of America
Magna-Tech Electronic Co., Inc.
Magni Systems, Inc.
MAG-ZON Inc.
Management Graphics, Inc.
Matthews Studio Equipment, Inc.
Maxell Corp. of America
McCurdy Radio Industries Ltd.
Merlin Engineering Works
Micron Audio Products, Ltd.
Microtime, Inc.
Microwave Radio Corp.
Midwest Communications Corp.
Miller Fluid Heads (USA) Inc.

3M Professional Audio/Video and Specialty Products Div.
Mitchell Camera Corp.
Mitsubishi Electric Sales America, Inc. Professional Electronics Div.
Mole-Richardson Co.
Montage Group, Ltd.
Moseley Associates, Inc.
Motion Picture Assn. of America, Inc.
Motion Picture Enterprises, Inc.
Motion Picture Promotion Corp.
Moviecam F. G. Bauer Filmtechnik GmbH
MPL Film & Video, Inc.
Multidyne Electronics, Inc.
NAC Inc.
Nagra Magnetic Recorders, Inc.
National Assn. of Broadcasters
National Broadcasting Co., Inc.
National TeleConsultants, Inc.
NEC America, Inc. Broadcast Equipment Div.
Neumade Products Corp.
NEVE
New England Digital Corp.
NHK Technical Services Co., Ltd.
Nikon Inc., Electronic Imaging
Norton Associates, Inc.
Novo Communications, Inc.
NURAD
NVision, Inc.
O'Connor Engineering Labs
Odetics, Inc. (Broadcast Div.)
Oki Electric Industry Co., Ltd.
Optical Disc Corp.
OSRAM Corp.
Otari Corp.
Pacific Radio Electronics
Pacific Title & Art Studio
Paltex
Panasonic Broadcast Systems Co., div. of Matsushita Electric Corp. of America
Panavision, Inc.
Pandora's Other Box Ltd.
Panther Corp. of America
PERROTT Engineering Labs, Inc.
Peterson International Ent. Ltd.
Philips Lighting Co.
Philips Components Discrete Products Div.
Photo-Sonics, Inc.
Pinnacle Systems, Inc.
Plastic Reel Corp. of America
Posso S.A.
Production Film Makers Associates Ltd.
Professional Film & Video Equip. Assn.
Quanta Corp.
Quantel
Rangertone Research Inc. Multi-Track Magnetics
Rank Cintel Inc.
Rank Film Laboratories Ltd.
Rank Taylor Hobson Ltd.
RDS Corp.
Rebo Studio
Redlake Corp.
Research Technology International/ Lipsner Smith Co.
Rosco Laboratories
RTS Systems
Ryder Sound Services, Inc.
Sachtler Corp. of America
Howard Schwartz Recording Inc.
Schwem Technology
Shoreline, Professional Video Systems
Showscan Film Corp.
Sigma Electronics Inc.
Sigma Film Equipment Ltd.
Skotel Corp.
Smart Theatre Systems
Solid State Logic Inc.
S.O.N. bv
Sony Corp. of America, Business and Professional Products Group
Sony of Canada Ltd. Communication Products Group
Spectra Systems, Inc.
Steadi-Film Corp.
Steenbeck, Inc.
Strand Lighting
Studer Revox America, Inc.
Sunburst Lighting Inc.
Tajimi Electronics Co., Ltd.
TASCAM — Prof. Div. of TEAC Corp.
Teccon Enterprises Ltd.
Technical Film Systems, Inc. (TFS)
Technicolor, Inc.
Technisphere Corp.
Tektronix, Inc., Television Div.
Teledyne Camera Systems
Telemetrics Inc.
Tentel Corp.
Theatre Equipment Assn.
Thomson Video Equipement
Tiffen Manufacturing Corp.
Time Logic Systems
Tintoretto, Inc.
Todd-AO/Glen Glenn Studios
Toei Chemical Industry Co., Ltd.
Truevision
TSM (Total Spectrum Manufacturing, Inc.)
TVC Laboratories, Inc.
Tyler Camera Systems
Ultimatte Corp.
Unilux, Inc.
Union Connector Co., Inc.
United Media, Inc.
Utah Scientific, Inc.
VEAM, div. of Litton Systems, Inc.
Video Accessory Corp.
Video Cable Comunicacion S.A.
Video Financial
Video Intl. Development Corp.
Videotek, Inc.
Vinten Equipment Inc.
Vistek Electronics Ltd.
WaveFrame Corp.
Wide Range Electronics Corp.
WIKO Ltd.
YCM Laboratories
Yokohama Cinema Laboratories, Inc.

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The SMPTE is a nonprofit organization that depends, in large measure, on the generous support of its Sustaining Members to conduct its many activities that benefit the motion-picture and television industries.

Throughout the year, the Society sponsors miniconferences, seminars, and hands-on workshops. These serve to augment the monthly section meetings as a means of providing the latest technical information to the people in our industry.

The Television Conference, which started modestly, has grown in status and prestige. It has become the premier forum for the introduction of new television technologies such as HDTV and digital television recording. The national conference is the largest annual gathering in the television and motion-picture industries devoted to the presentation of technical papers and the interchange of ideas.

One of the most important activities in which the Society engages is in the aiding of establishing standards. Most notable recently was the establishment of the "C" format for 1-in. television recording and the Type D-1 Digital Video Recording standard. Current efforts concern production standards for HDTV and investigation into the feasibility of 30 frames/sec as a new film production standard.

These activities have direct bearing on your organization's future, and members of your staff may already be involved in these engineering projects as individuals. Your support, at the corporate level, will help insure that these vital activities can continue.

In addition, here are some specific benefits of SMPTE Sustaining Membership:

- Listing of your company within the monthly *SMPTE Journal.*
- A complete description of your company and its services in the SMPTE annual *Directory for Members.*
- A subscription to the *SMPTE Journal* and the Society's monthly newsletter.
- A wood-mounted, metallic plaque.
- A press release announcing your company's joining the SMPTE.
- A discount for exhibiting at the SMPTE Technical Conferences.
- The distinction of being among more than 270 companies and organizations supporting the aims and activities of the SMPTE.

The Society invites applications for Sustaining Membership from other interested companies • Information may be obtained from Charles H. Jablonski, Chairman, Sustaining Membership Committee, NBC, 30 Rockefeller Plaza, New York, NY 10112, or from Society Headquarters. • Addresses and descriptions of Sustaining Members appear in the *Directory for Members*, published in April 1990.

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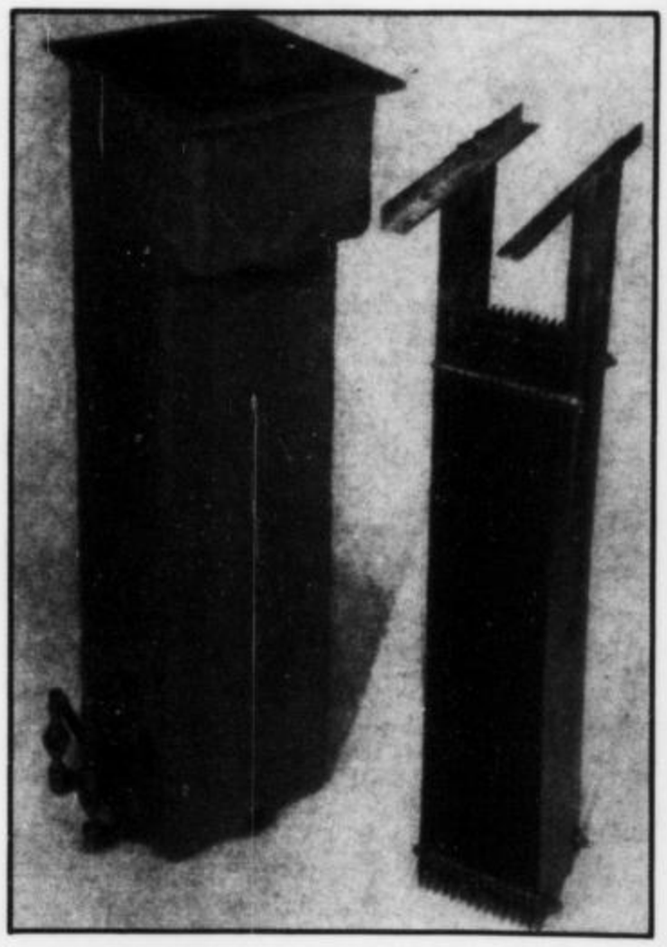
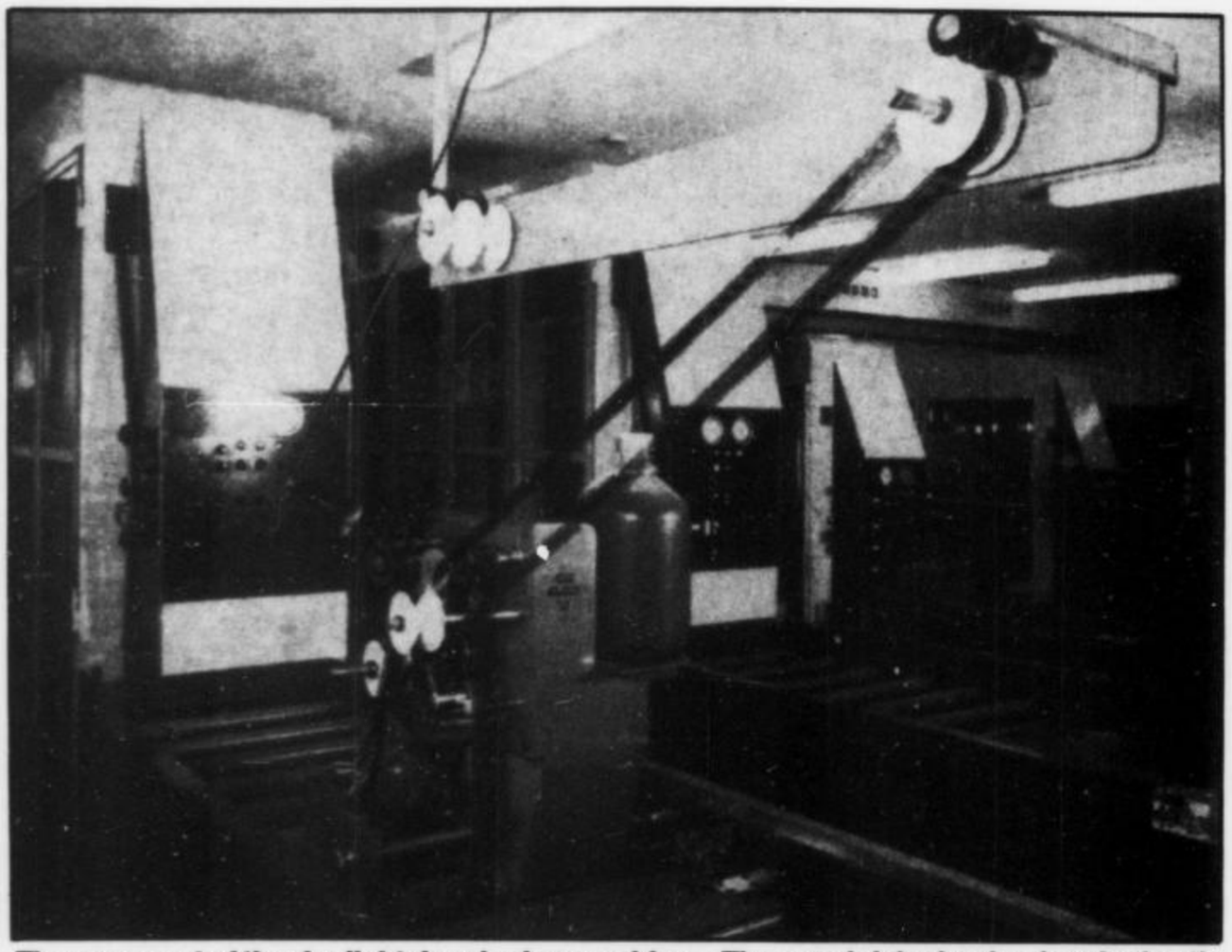
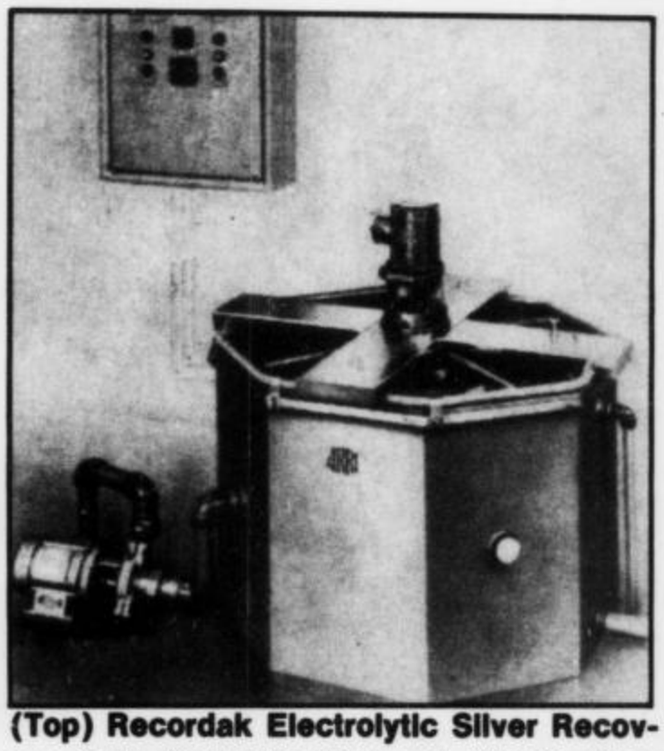
SMPTE Historical Reflections

Multi-unit vehicle with color and monochrome camera, audio, switching and terminal facilities • *Television Mobile-Unit Design* • *I. S. Rosner* • *JSMPTE, June 1965.*

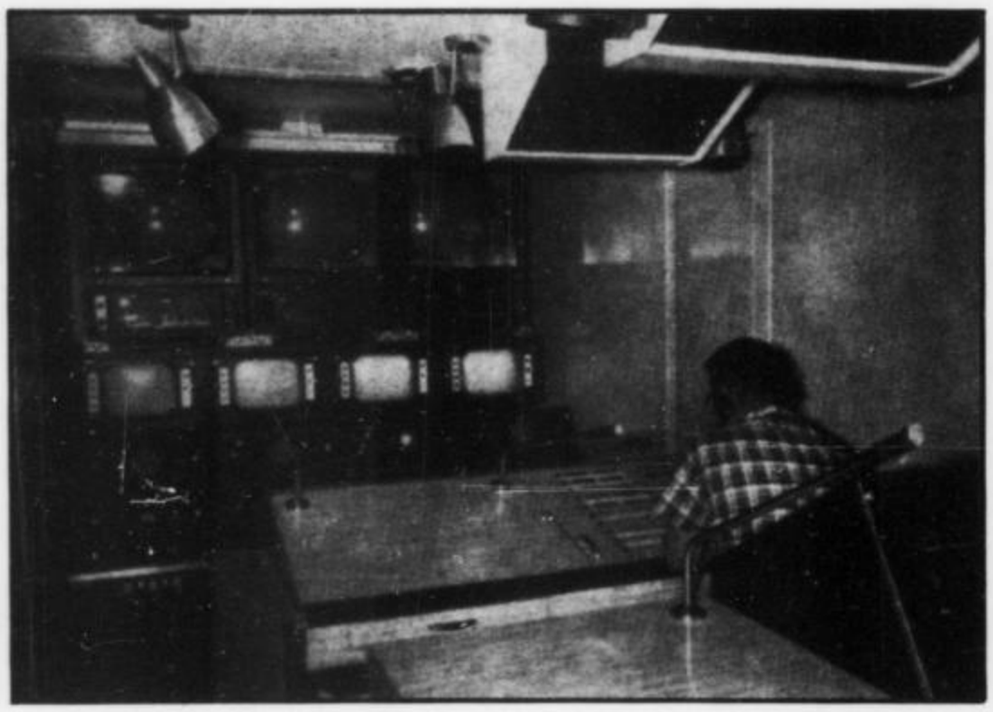


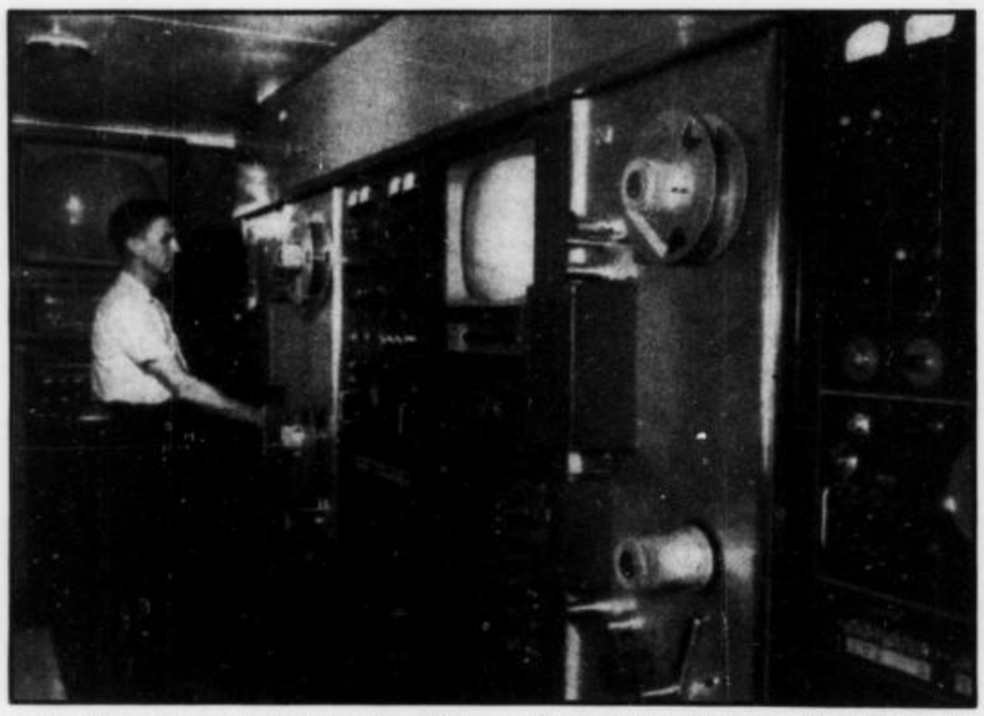


The open part of the daylight developing machines. The special device for developing the soundtrack on color film is shown • *Daylight Film Processing Laboratory* • *S. Dahlstedt* • *JSMPTE, June 1965.*



(Top) Recordak Electrolytic Silver Recovery Cell, Model 3; (Bottom) "Arri" silver recovery plant • *Present Status of Silver Recovery in Motion-Picture Laboratories* • *M. L. Schreiber* • *JSMPTE, June 1965.*





(Left) Interior view of camera unit; control center; (Right) Interior view of video-tape unit; tape facilities • *Television Mobile-Unit Design* • *I. S. Rosner* • *JSMPTE, June 1965.*